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FLAMINGOES DURING THE NESTING SEASON.

THE FLAMINGO AND ITS QUEER NEST.

After considerable difficulty, Prof. Frank M. Chapman, of the Department of Ornithology of the American Museum of Natural History, has secured the first flamingo nests ever brought to this country.

There are about seven species of flamingoes, three of which are in America, frequenting the Bahamas, Florida, and Cuba. In height the flamingo averages about five feet. If its curved neck were stretched to its full length the bird would tower above the head of an ordinary man. During May and June, the breeding time, the birds' bright-colored plumage is faded, but reassumes its most radiant hues in winter. When first hatched the young have a straight bill, which, after a time, develops into one of bent shape. The first plumage is grayish-white and passes through various tints of pink, rose, carmine, or vermilion to the full scarlet of the adult, which reaches its deepest shade on the wings. Several years are necessary to perfect the final gaudy plumage.

The eggs are white, showing a blue tint when scraped under the surface. They are long, oval, and have a thick shell, equaling in size that of the common goose. The flesh is not palatable to the taste, being extremely oily. The birds feed upon both animal and vegetable matter from the ooze and soft bottoms of the shallow waters and lagoons selected by them both as a feeding ground and nesting place. When flying their long legs are stretched out behind, and the neck is extended. They have a peculiar voice and a sort of one-syllable outcry, which they utter as an alarm signal the moment they are approached or believe themselves to be in danger. On account of their keen-eyed and wary nature it is almost impossible to get within close range of them.

Prof. Chapman gives the following account of his work in the Bahamas:

During the winter the birds live chiefly on the west coast of the island, where the shallow water and soft marl bottom afford them an abundance of food and prevent pursuit either by boat or on foot; but in May they gather in some lagoon in the interior of Andros Island, far from the habitations of man, to rear their young. These breeding resorts are few in number and their whereabouts are comparatively unknown. We succeeded in reaching a large flamingo rookery well in the heart of Andros without undue difficulty. Our schooner was left at anchor behind the shelter of some outlying reefs, and the final part of the voyage was made in small boats.

The locality is only a few inches above the sea level, and is characterized by wide stretches of shallow lagoons bordered by red mangrove trees, with occasional bare bars of gray marl, and by outcrops of coralline rock so eroded and waterworn into bladelike edges and sharp, jagged pinnacles, that walking is attended by much danger. Our tents were pitched on a sand bar, and preparations made to visit the flamingo colonies known to exist in the vicinity.

Subsequent research showed that the locality was regularly frequented by these birds as a breeding resort, but that apparently a different spot was chosen each year. Eight groups or villages of nests were found within a radius of a mile, each evidently having been occupied only one year. The largest of these, placed on a mud bar only an inch or two above the level of the surrounding water, was a hundred yards in length, and averaged about thirty yards in width. An estimate, based on an actual count of a portion of this colony, gave a total of two thousand nests for an area of, approximately, only 27,000 square feet. This rookery we judged to have been occupied the previous year. At a distance of a mile we found nests scattered about in a dense growth of mangroves. Here the birds were found at work upon their nests for the present year.

A flock was seen which was estimated to contain about seven hundred birds—a sight of surpassing beauty. Although no shot was fired and a retreat was promptly made, the birds were disturbed by our

A FLAMINGO EGG IN ITS NEST OF MUD.

intrusion, and either discontinued operations or removed to some other locality, and eventually we were forced to leave without seeing fresh nests. Those in progress of building, however, told somewhat the manner of their construction. Those built among the mangroves were in an excellent state of preservation, a few even containing eggs. The task of getting these nests into the hold of the schooner was one of great difficulty. The largest secured measured 18 inches in diameter at the bottom, 13 inches at the top, and 9 in height, and weighed upward of 100 pounds.

THE BAHAMA FLAMINGO.

Being one solid mass of mud and dried only externally, it needed only a slight jar to break the strongest of the nests into fragments, and the prospect of transporting the specimens to New York in safety seemed one of uncertainty. The Bahama negro boatmen were not accustomed to delicate work of this

COLONY OF FLAMINGO NESTS, BAHAMA ISLANDS.

character, and it required special inducements in the way of pay to tempt them to wade barefooted through the lagoons and to travel over the keen-edged rocks with burdens of from 50 to 150 pounds on their heads.

The nests were placed in the canoe and reached the schooner with the breaking of only three out of nine specimens. In Nassau they were treated with a solution of gum arabic, which hardened them, and after being wrapped in plaster of Paris bandages they were packed separately in large boxes and reached New York in excellent condition. Specimens of the flamingoes themselves were also secured. The nests collected differed from the conventional idea of flamingos' nests in being much lower and of a greater diameter. Doubtless the height of the nest is governed by the rise of the water. Built wholly of mud, which is scooped up from about the base of the nest by the bird, it is necessary that the site chosen shall be near enough to water to insure an abundant supply of soft material. Such a site, however, brings the nest within reach of the tide, and places it in a low situation, which may be subsequently flooded by heavy rains. Consequently the birds must build their nests high enough to protect their contents from the water.

These two conditions have resulted in the production of a mud cone, which, in the colonies examined, was never more than twelve inches in height, but those as high as eighteen inches have been reported. In the slightly hollowed top of the adobe dwelling house a single white egg is laid.

The single nest here figured, however, has been excavated to a greater depth than the original in order to lighten it for transportation purposes.

A NEW HIMALAYA MOUNTAIN CLIMBING RECORD.

A new record in mountain climbing has been established by the two well known explorers, Dr. and Mrs. Workman in the Nun Kun range of the Himalaya mountains. For some time past these two mountaineers have devoted considerable time to the exploration of this little known mountain range, the results of which have been the securing of much valuable information concerning the geographical and topographical features and the flora of these mountains. Hitherto their efforts have been mainly devoted to the climbing of the lower peaks, but a few months ago they completed arrangements for the investigation of some of the higher crests. For this purpose they established a base camp for their main caravan at an altitude of 14,400 feet in the Shappat Nala. The camp consisted of seventy coolies, fifteen goats, and twenty-five sheep.

From this base they decided to carry out their exploration work. Accompanied by seven Italian guides and porters, who were specially selected from the Swiss Alps on account of their wide experience in mountaineering, and fifteen coolies they set out from the camp on July 25 last for the upper snows. On the first day progress was fairly rapid, an altitude of 17,200 feet being reached before they camped for the night. At this elevation the party were surrounded by brilliant verdure and many specimens of flora hitherto unknown were found, including a flower which thrives prolifically, and which has never been found before on the slopes of the Himalayas.

The ascent was resumed on the following day, but owing to the difficult nature of the ground and the approach to the snow limit, progress was slower, a climb of 2,258 feet being effected. On this day the camp was pitched for the night upon a sloping snow reach and a rearrangement of the accompanying party in view of the difficult work immediately confronting them, effected. All the coolies, with the exception of two, who volunteered to proceed with the explorers, were instructed to return to the base camp. At this point a huge ice wall of exceptional steepness and treacherous in character confronted them, but after much labor this was finally negotiated and a rolling plateau encircled by the lofty peaks of the Nun Kun range was reached. A heavy mist and snow "flurries," which were encountered at this point, rendered the going unduly heavy and exceptionally dangerous, so that at last it was finally decided to camp, the elevation at this point being 20,730 feet.

The weather moderating somewhat the next day the journey was continued, a further 500 feet being climbed and the highest camp that has ever been pitched in mountaineering was here formed and called "Camp America" at an altitude of 21,200 feet and situate at the base of the highest peak. The Italian porters who had accompanied their explorers and their guides deposited their loads of 40 pounds each at this camp and returned to the lower level for additional supplies since, owing to the extreme altitude at which they were camped and the uncertainty of the weather, it was decided to lay in adequate supplies in case they became stormbound. As a matter of fact the weather became so bad that the porters and guides could not reach the camp again that night and the explorers passed the night alone in the midst of a dense fog and with the thermometer registering 4 deg. F. The

cold was intense and the boots of Dr. and Mrs. Workman, although copiously greased, were frozen as solid as a block of ice. Early the next morning a guide and two porters succeeded in regaining the camp and the weather having cleared sufficiently, it was decided to renew the climb.

From this point onward to the summit of the peak progress was slow and difficult. For four hours the party had to cut their way in steps over the frozen snow and ice. When an altitude of 22,800 feet was reached a halt was made for food, and while Dr. Workman and one porter remained behind, Mrs. Workman with a guide and porter pushed forward to the summit of the peak 350 feet above. By dint of considerable exertion this was at last attained. The view from the summit is described as magnificent in the extreme. Although the panorama unfolded below them was somewhat interrupted by clouds, they were able to see for miles over the lower ranges to Wanga Parbat and the Karakoram. In reaching the top of this peak Mrs. Workman established a world's record in mountaineering, the altitude being 23,150 feet. After a short stay the descent was made, and finally after many hardships the base camp in the Shappat Nala was regained. Altogether six nights were spent in camping on the snow. The greatest hardship from which the party suffered after passing a height of 19,000 feet was insomnia.

ASPHYXIATION IN SHIP HOLDS.

The cases of illness or sudden death in badly ventilated ship holds kept closed for some time, which have been frequently recorded, have hitherto been attributed to the evolution of carbon monoxide or to an excessive accumulation of carbonic acid. Experiments recently made by G. Giemsa (see Gesundheits-Ingenieur, No. 36) have, however, shown the noxious effects to be due rather to an absorption of oxygen than to any of the foregoing causes.

After keeping some substances such as those generally loaded by ships for some time in bottles the percentage of oxygen and carbonic acid in the air of the latter was determined. The bottle was kept either moist or dry, while the temperature was maintained either at ordinary figures or 28 deg. C. (81.4 deg. F.)

All the substances investigated were found rapidly to absorb oxygen, so as to reduce the percentage of this gas to zero under favorable circumstances. In the case of linseed cake, resin, and Indian corn, the absorption was favored by the high moisture of the surrounding air and the increased temperature. Whenever bacterial or germinative processes occurred, as in the case of Indian corn, a large evolution of carbonic acid would attend the absorption of oxygen.

The influence of pure water and of water containing organic impurities was next tested, because of the accidents that had occurred in water tanks. It is shown that, while pure water exerts practically no effect, a lively growth of bacteria will take place in water to which a bouillon has been added; this process is attended by an evolution of carbonic acid and absorption of oxygen.

How important these results are for hygienical practice generally may be inferred from the fact that the drying process of certain floor varnishes is attended by a considerable absorption of oxygen. The noxious effects on the air in badly ventilated and overcrowded assembly halls are likewise attributable to the absorption in question.

Experiments made on animals have shown death to occur as rapidly as in 30 to 40 minutes, in the case of air containing 14 per cent oxygen, while even so small a percentage as 15 or 16 per cent still exerts some striking noxious influence on the animals. This goes to show that dwelling in a room the air of which holds less than 15 per cent of oxygen will be fatal to man.

In order to ascertain whether the air in a given room is respirable, Mr. Giemsa suggests lowering cages with mice, the condition of which is afterward examined; this method may in fact be used even with relatively high percentages of oxygen (16 per cent or 17 per cent) in connection with which the extinguishing of a candle fails to give any reliable results.

THE MYSTERIOUS STATUES OF EASTER ISLAND.

By the English Correspondent of Scientific American.

Far out in the Pacific Ocean, some 2,000 miles from the nearest mainland, in latitude 27 south and longitude 109 deg. west, lies a small inhospitable rocky islet known as Easter Island. So remote is this little colony from the beaten tracks of vessels that for months the inhabitants receive no news of the outer world, and communication is for the most part maintained only by the visit of one of the British warships at long intervals, which is specially deputed for calling at the other inaccessible islet, Pitcairn Island, and at the same time often visits this Chilian insular possession.

To the archæologist Easter Island possesses exceptional interest inasmuch as its history and that of its people is absolutely unknown, the only intimation available as to its ancestors being through the fantastic and unauthoritative mediums of tradition and legends. The island teems with remarkable and colossal statues, the handicraft of an almost extinct race, and with numerous mysterious hieroglyphics and inscriptions upon the walls of the remaining buildings to which as yet no solution has ever been found. Popular supposition connects this strange and out-of-the-way abode somewhat hazily with the mysterious ancients of the Andes, since the native carvings upon the island bear a striking resemblance to those found of the Aymara, one of the ancient civilizations of Peru, but upon this point no tangible evidence has yet been advanced, owing doubtless to the fact that the remains to be found on Easter Island have never yet been the object of a thorough and careful archæological investigation, due, no doubt, to the inaccessibility of the island.

The total population to-day of Easter Island, or to quote its native name, Rapu Nui, according to the results of recent periodical visits of the British war vessel "Flora," number only 226, of which total there are 108 males and 118 females. These are the remaining descendants of the ancient race that originally peopled this island, but in the course of ages their physique has wofully deteriorated, and it is almost as impossible to associate the tremendous monuments that are to be found upon the island with such a race as it is to associate the present Egyptians with the colossal works that were raised in the times of the Pharaohs.

According to the tradition of these existing natives, their ancestor was Hotu Metua—Prolific Father—who came to the island in a canoe, with his queen in another similar vessel. They first discovered this island, which at that time was unpeopled, and named it "Tepito fenua," which signifies the land in the middle of the sea. At all events, they landed and made the island their future home. Whence they came is wrapped in mystery, and legend, which is invariably so convenient for the explanation of a mystery, is unusually silent upon this point.

The remarkable statues for which the island is famous are abundantly scattered over the island and are of the most gigantic dimensions, recalling the strange tombs of the Ming dynasty in China. The statues consist only of the head and trunk, and rear their heads to a height ranging from 15 to 20 feet, and are of enormous weight. One statue, however, which is stated to be raised to the memory of an ancient ruler of the race, towers above the others, the height from the ground to the top of the head being 34 feet. The statues are carved out of lava, since the island is of volcanic formation, though the volcanoes have long been extinct. This material is grayish in color and of very close texture and is known as trachyte, being quarried out of the crater of the extinct volcano Otu-iti. In this crater the long disused cuttings whence this stone was obtained may yet be seen. The statues are decorated with strangely fashioned crowns of a red lava, excavated from the crater of another extinct volcano, Terano Hau. It is known as tufa and is soft and friable, like red clay, but is only to be found on the island in the crater of this particular volcano, which is situated about a dozen miles from Otu-iti.

These colossal statues are raised over the tombs, and for the most part are to be found on a magnificent terrace sloping down to the seashore. The graves themselves are no less extraordinary, comprising huge stones rolled into position, and skillfully fitted together. Upon these stones is placed a platform fashioned out of one bowlder. These graves are of immense proportions, the outside measurements in some instances approximating 90 feet in length by 30 feet in width. In the majority of cases the uppermost stone, forming the lid of the grave and providing a platform for the supposed statue, weighs over one ton. In addition to these statues the platform is additionally provided with mysterious altars, upon which evidently sacrificial rites were carried out, since charred bones have been found scattered around them. From the results of the cursory examinations that have been made of these tombs, the body was apparently lowered into the stone-inclosed area and sealed by the fitting of the huge monolith on top, the statue being raised at a subsequent date. Evidently when a person of high rank, such as a chief, was buried, the body was escorted into the tomb by a living companion, since in some of the graves more than one set of bones have been observed.

In addition to these remarkable statues, there are to be found in one part of the island, at a point farthest removed from the volcano Otu-iti, a large number of stone huts which are evidently of great age. They are square in shape and entered by a narrow orifice two feet wide. Evidently at the period when these huts were built the island suffered severely from the ravages of the volcano, and at such times of eruption the natives sought refuge from the molten lava and fire in these roomy huts, and apparently brought with them their treasures, since the huts are in every case provided with large recesses in which such possessions could be temporarily stored.

The faces of the tombs, the interior walls of the refuge huts, and the faces of the quarries are freely inscribed with hieroglyphics, the meaning of which has not yet been fathomed. There is no doubt but that if the key to these mystic symbols could be found the veil of mystery which at present surrounds many of the long by-gone races of the South Americas would be lifted and valuable data concerning an extinct civilization obtained. Certain it is, however, that there is a more or less closely connecting link, from the similarity of the hieroglyphics, between the original people of Easter Island and the ancient Peruvians.

JESUITS IN SCIENCE.

In nature study, as well as in mathematics, pure and applied, the Jesuit in the early post-Renaissance period made his mark in nearly every department, and the missionaries of the society overran the new world and the unexplored regions of the old, making converts to the Church and enriching the scientific knowledge already theirs by concurrent observation and research.

What visitor to the Vatican has failed to be struck, in the Gallery of the Geographical Maps, with the sagacity of the missionaries who framed them—the watershed of sub-equatorial Africa, for example, being given, hypothetically indeed, but with an approximate accuracy which it was reserved for the latter half of the nineteenth century to complete and to ratify? Again, what student of the medical past has forgotten the beautiful story of the discovery of the quinine-bearing cinchona and the introduction into the physician's armory of "Jesuits' bark," first exhibited in the seventeenth century, and since then by pharmaceutical refinements developed into the salt which is to the European sojourner in the tropics what the Davy lamp is to the miner?

Even in the modern day the Jesuit remains true to his scientific traditions; witness those worthy descendants of the Pere Boscovich—the Padre Secchi, famed for his "Solar Physics," and his successor in the directorate of the Vatican Observatory, the Padre Denza. The latter, indeed, besides his work in seismology perpetuated on identical lines by members of the society throughout Italy, will always be remembered for his demonstration of the origin of that scourge of the Mediterranean seaboard, the wind known as the "sirocco." Having surmised that the said wind was always coincident with a sand storm in the Sahara, he stationed a correspondent at the borderland between the Tel, as cultivated Algeria is called, and the great desert, with instructions to telegraph to him on the Italian littoral whenever a sand storm was brewing. On came the wind, the Padre Denza being duly prepared for its advent, at various points of the Italian shore, with huge facades of cardboard wet with gum. And sure enough, as it passed over sea inland a thick layer of sand was deposited on the facades, thus explaining what had been observed, but not traced to its cause, by Celsus, namely, the sense of heat, of weight, of general depression and lowered vitality experienced during the prevalence of the sirocco—an experience not to be escaped till, by reclamation and crop culture, the Sahara ceases to be the sand ocean it has been.

Inspired by the traditional genius of the society, the Padre Massaia in his thrilling record of mission work forty years ago in the Galla country (west of Abyssinia), ascribes to his nature study and his command of the healing art the success of the enterprise which brought him the gratitude of the Pope and the title of Cardinal. Setting out as a simple monk about the middle of the last century long before the opening up of Egypt to civilization and the present facilities for travel, he reached the scene of his labors with only the Bible and the crozier of St. Francis. First he began to make friends with the savage natives by teaching them the arts of peace and of civilized life—down to tenement structure, cooking and clothing. All this time he was quietly mastering their language till he constructed its grammar for them, and finally translated into it portions of Holy Writ. Then he set up a printing press (thanks to subsidies from the Propaganda) and taught the younger of the natives to read. Still his progress—well nigh single handed—was slow, till the periodical outbreaks of smallpox gave him his opportunity. He vaccinated as many of the natives as he could prevail upon to submit to the operation, and when the tribe at the next epidemic of the disease found his patients immune, while those who had held back from becoming so either died or emerged from it disfigured, their liking for him deepened into love and a superstitious belief in his power. The success of his mission was then assured.

But it was in the degree in which they re-enforced religion with science, above all with the healing art in its widest sense, clinical and hygienic, that the Jesuit apostles effected their most salutary work—a work which made them the progenitors, so to speak, of Livingstone and Bishop Pattison.

The chemical nature of caoutchouc is a subject which has attracted the attention of distinguished chemists from the middle of the eighteenth century, among them being Faraday, Liebig, and Dalton. Faraday was the first to examine the constituents of the latex of *Hevea brasiliensis*. It is only in recent years that our knowledge of the constitution of organic compounds, and especially of the terpene group, has rendered it possible to make any great advance. It is interesting to record that Greville Williams, in 1860, made most important contributions to this subject. He identified a new hydrocarbon, isoprene, as a decomposition product of caoutchouc, and recognized its polymeric relation to caoutchouc. The results obtained from the analytical side, and especially the formation of di-pentene and isoprene by pyrogenic decomposition of caoutchouc, had pointed to the fact that caoutchouc was essentially a terpenoid polymer of the formula $C_{10}H_{16}$. Harries finds, however, that the ozonide of caoutchouc, when distilled with steam, breaks up into lævulinic aldehyde, lævulinic acid, and hydrogen peroxide, and he concludes from this that caoutchouc is a polymer of a 1:5 dimethyl cyclo octadien. While Harries's work has brought us much nearer the goal, and has led to the discovery of a new method of investigation through the ozonides, which is obviously of wide application, it cannot yet be said that the constitution of caoutchouc has been settled or its relation to the parent substance of the latex definitely established. It has still to be shown how a closed-chain hydrocarbon such as Harries's octadien can undergo polymerization forming the colloid caoutchouc.

METHODS OF MEASURING VELOCITIES OF PROJECTILES AND PRESSURES IN CANNON.*

By MAJOR ORMOND M. LISSAK, U.S.A.

MEASUREMENT of Velocity.—In measuring the velocity of a projectile the time of passage of the projectile between two points, a known distance apart, is recorded by means of a suitable instrument. The calculated velocity is the mean velocity between the two points, and is considered as the velocity midway between the points. In order that this may be done without material error, the two points must be selected at such a distance apart in the path of the projectile that the motion of the projectile between the points may be considered as uniformly varying, and the path a right line.

Le Boulengé Chronograph.—The instrument generally employed for measuring the time interval in the determination of velocity was invented by Capt. Le Boulengé of the Belgian artillery, and is called the Le Boulengé chronograph. It has been modified and improved by Capt. Bréger of the French artillery. The brass column, *a*, Fig. 1, supporting two electro-magnets, *b* and *c*, is mounted on the triangular bed plate, *d*, which is provided with levels and leveling screws. The magnet, *b*, supports the long rod, *e*, called the chronometer, which is enveloped when in use by a zinc or copper tube, *f*, called the recorder. The magnet, *c*, which supports the short rod, *g*, called the registrar, is mounted on a frame which permits it to be moved vertically along the standard. Fastened to the base of the standard is the flat steel spring, *h*, which carries at its outer end the square knife, *i*. The knife is held retracted or cocked by the trigger, *j*, which is acted upon by the spring, *k*. The chronometer, *e*, hangs so that one element of the enveloping tube or recorder is close to the knife. When the knife is released by pressure on the trigger it flies out under the action of the spring, *h*, and indents the recorder. The registrar, *g*, hangs immediately over the trigger. When the electric circuit through the registrar magnet is broken the registrar falls on the trigger and releases the knife. The tube, *l*, supports the registrar after it has fallen through it. Adjustable guides are provided to limit the swing of the two rods when first suspended. The stand or table on which the instrument is mounted is provided with a pocket which receives the chronometer when it falls, at the breaking of the circuit that actuates its magnet. A quantity of beans in the bottom of the pocket arrests the fall of the chronometer without shock.

Accessory Apparatus.—To use the instrument for the measurement of velocity of a shot two wire targets, each made of a continuous wire, Fig. 2, are erected in the path of the projectile. The targets form parts of electric circuits which include the electro-magnets of the chronograph. Each magnet has its own target and its own circuit independent of the other. The circuit from the nearer or first target includes the chronometer magnet; the circuit from the second target includes the registrar magnet. On the passage of the projectile through the first target the circuit is broken, the chronometer magnet demagnetized, and the long rod, or chronometer, falls. When the projectile breaks the circuit through the second target the short rod or registrar falls, and striking the trigger releases the knife which flies out and marks the recorder at the point which has been brought opposite the knife by the fall of the chronometer.

The chronometer circuit is led through a contact piece not shown, carried by the spring, *h*, Fig. 4, and so arranged that the chronometer circuit cannot be closed until the knife is cocked. This arrangement prevents the loss of a record through failure to cock the knife when suspending the rods before the piece is fired.

The Rheostat.—Both circuits are led independently through rheostats, by means of which the resistance in the circuits may be regulated, and the strength of the currents through the two magnets equalized. One form of rheostat is shown in Fig. 3. The current passes through the contact spring, *a*, and through a German-silver wire wound in grooves on the wooden drum, *b*. By turning the thumb nut, *c*, the contact spring is shifted, and more or less of the wire is included in the circuit.

Another form of rheostat, through which both circuits pass independently, is shown in Fig. 4. Each current passes through a strip of graphite, *a*, and the resistance in the circuit may be increased or diminished by sliding the contact piece, *b*, so as to include a greater or less length of the graphite strip in the circuit.

The Disjunctor.—Both circuits also pass independently through an instrument called the disjunctor, by means of which they may be broken simultaneously. The disjunctor is shown in elevation and part section in Fig. 5. The two halves of the instrument are exactly similar. The two contact springs, *c*, weighted at their free ends, bear against insulated contact pins, *e*, supported in a metal frame, *d*. The frame is pressed upward against the spring catch, *h*, by two other contact springs, *f*. The electric circuit passes from one binding post through the parts, *f*, *e*, *c*, and *a*, to the other binding post.

On the release of the spring catch the frame, *d*, flies upward under the action of the springs, *f*, until stopped by the pin, *g*. At the sudden stoppage of the movement the weighted ends of the contact springs simultaneously leave the contact pins, thus breaking both circuits momentarily. Mounted on a shaft are two hard rubber cams, *b*, which bear against other springs, *a*, in the two circuits. On turning the camshaft the connection between the parts, *a* and *c*, is broken, breaking both electric circuits but not necessarily simultaneously. The circuits are habitually broken in this manner except when taking disjunction or records in firing.

Disjunction.—By means of the disjunctor both cir-

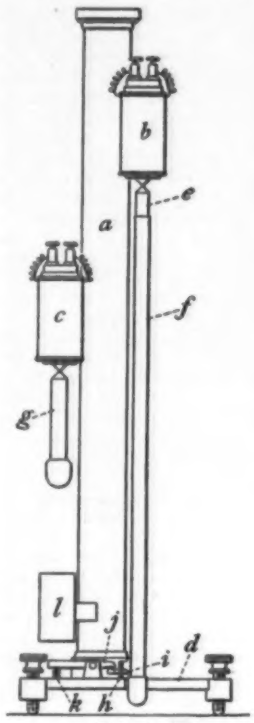


FIG. 1.

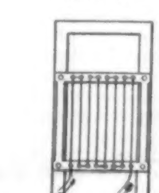


FIG. 2.

FIG. 6.

cuits are broken at the same instant. The mark made by the knife under these circumstances is called the disjunction mark, and its height above a zero mark made by the knife when the chronometer is suspended from its magnet is evidently the height through which a free falling body moves in the time used by the instrument in making a record. This time includes any difference in the times required for demagnetization of the two magnets, the time occupied by the registrar in falling, and the time required for the knife to act.

From the height as measured we obtain the corresponding time from the law of falling bodies

$$t = (2h/g)^{\frac{1}{2}}.$$

Now when the circuits are broken by the projectile the chronometer begins to fall before the registrar. The mark made by the knife will therefore be found above the disjunction mark. If we measure the height of this second mark above the zero, the corresponding time is the whole time that the chronometer was falling before the mark was made, and to obtain the time between the breaking of the circuits we must subtract from this time, the time used by the instrument in making a record, or the time corresponding to the disjunction. Let h_1 and h_2 represent the heights of the disjunction and record marks, respectively, t_1 and t_2 the corresponding times. Let t be the time between the breaking of screens, then

$$t = t_2 - t_1 = (2h_2/g)^{\frac{1}{2}} - (2h_1/g)^{\frac{1}{2}}.$$

It will be seen by the equation that *the difference of the times, and not the difference of the heights must be taken.*

Measuring Rule.—For measuring the height of the mark on the recorder above the zero mark there is provided with the instrument a rule graduated in millimeters, and with a sliding index and vernier, the least reading being 1/10 of a millimeter. The swiveled pin at the end of the rule, Fig. 6, is inserted in the hole through the bob of the chronometer, and the knife edge of the index is placed at the lower edge of the mark whose height is to be measured. The height is then read from the scale. Tables are constructed from which can be directly read the time corresponding to any height in millimeters within the limits of the scale. The maximum time that can be measured with this chronograph is limited by the length of the chronometer rod, and is about 0.15 of a second.

Adjustments and Use.—The chronograph must be properly mounted on a stand at such a distance from the gun that it will not be affected by the shock of discharge. The electrical connections with the batteries and targets, through the rheostats *r* and disjunctor *d* are made as shown in Fig. 7.

The instrument is leveled and adjusted, the circuits are made through the disjunctor and rheostats, and the chronometer and registrar rods are suspended from their respective magnets.

To regulate the strength of the magnets each of the rods is provided with a tubular weight, one tenth that of the rod. These weights are slipped over the rods before suspension and by means of the rheostats the resistance in each circuit is slowly increased until the rod falls. The chronograph is then in adjustment, and the weights are removed from the rods.

The circuits through the targets are also tested by suspending the rods and then breaking the circuits successively at the targets. The proper rod must fall as each circuit is broken.

When the gun is loaded and ready for firing, the rods are again suspended. When the piece is fired, the projectile passes through the screens, breaking the circuits and causing the rods to fall. The interval between the times of falling of the two rods, which is measured by the instrument, is the time of flight of the projectile over the measured distance between the two screens.

Circuits are always broken at the disjunctor when the rods are not actually suspended, and the rods are allowed to remain suspended as short a time as possible.

Targets.—The first target must always be erected at such a distance from the gun that it will not be affected by the blast. For small arms it is placed three feet from the muzzle and consists of fine copper wire wound backward and forward over pins very close together. For cannon it is placed from 50 to 150 feet from the muzzle, depending upon the size of the gun. For the measurement of ordinary velocities the targets are usually placed, for small arms, 100 feet apart, and for cannon, 150 feet.

The second target for small arms consists of a steel plate to stop the bullets, having mounted on its rear face, and insulated from it by block *w*, Fig. 8, a contact spring, *s*, contact pin, *p*, and their binding screws. When the bullet strikes the plate the shock causes the end of the spring to leave the pin, and thus breaks the circuit, which is immediately re-established by the reaction of the spring. By means of this device constant repairing of the target is avoided.

Measurement of Very Small Intervals of Time.—For the measurement of very small intervals the registrar magnet is raised to near the top of the standard and placed in the circuit with the first target. The chronometer magnet is put in the circuit with the second target. Under this arrangement the disjunction mark will be made near the top of the recorder

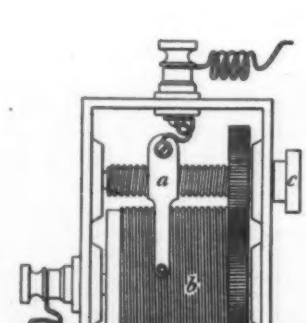


FIG. 3.

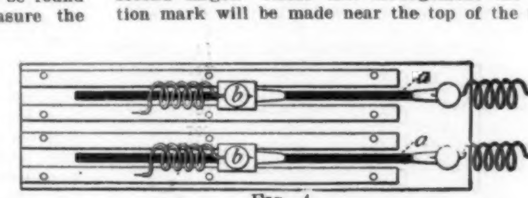


FIG. 4.

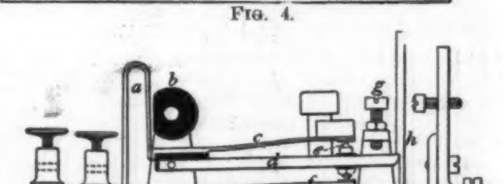


FIG. 5.

and the record mark under the disjunction. The interval of time measured is obtained by subtracting the time corresponding to the height of the record mark from the time of disjunction. The object of this arrangement is to obtain the record when the chronometer has acquired a considerable velocity of fall, so that the scale of time will be extended, and small errors of reading will not produce large errors in time.

Schultz Chronoscope.—The Le Boulengé chronograph measures a single time interval only. When it is desired to measure the intervals between several

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

successive events an instrument that provides a more extensive time scale is required.

The Schultz chronoscope is an instrument of this class. An electrically sustained tuning fork, *c*, Fig. 9, whose rate of vibration is known, carries on one tine a quill point, *b*, which bears against the blackened surface of the revolving cylinder, *a*, and marks on it a sinusoidal curve which is the scale of time. By giving motion of translation to the cylinder past the fork the time scale may be extended helically over the whole length of the cylinder. The records of

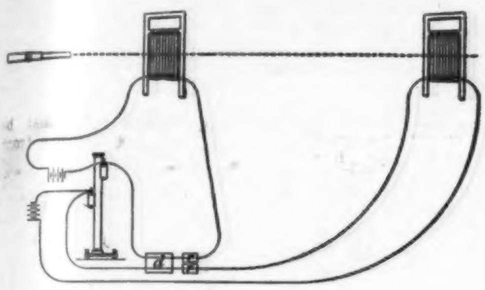


FIG. 7.

events, such as the passage of the shot through screens, are made by the breaking of successive circuits which pass through the Marcel Deprez registers, shown at *e*, Fig. 9, and in Fig. 10. When the circuit is broken the magnet, *e*, Fig. 10, is demagnetized, and the spring, *g*, rotates the armature, *f*, and the quill, *h*, attracted to it. This marks a bend or offset in the trace of the quill on the revolving cylinder and the point of the bend referred to the time scale marks the instant of the breaking of the circuit.

The Sebert Velocimeter.—This instrument is used to record the movement of the gun in free recoil, that is, when it is so mounted that it recoils horizontally and with very little friction. A blackened steel ribbon, *S*, Fig. 11, is attached by the wire, *T*, to a bolt projecting from the trunnion of the gun. As the gun recoils it pulls the ribbon past the tuning fork, *A*, and registers *R*. The time scale and register records are made as described under the Schultz chronoscope. The actual distance traversed by the gun at any instant is the distance from the origin of the time scale to the point on the scale that marks the instant considered. The time scale is therefore a complete rec-

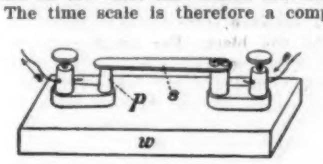


FIG. 8.

ord of the movement of the gun, and from it the velocity of the gun at any instant may be determined. From the velocities of the gun the velocities of the projectile may be determined and the pressures necessary to produce these velocities.

The registers have no function in the measurement of the recoil proper, but may be used to record any event happening while the recoil record is being made. The instant of the departure of the projectile from the bore is usually thus recorded, and independent measurement of the velocity of the projectile between points in the bore may also be made.

Methods of Measuring Interior Velocities.—Two methods that have been used in determining the instant of the projectile's passage past selected points in the bore are shown in Figs. 12 and 13.

Some circuit-breaking device is used at the points selected and the electric wires are led to any suitable velocity instrument.

Measurement of Pressures.—Pressures in cannon are

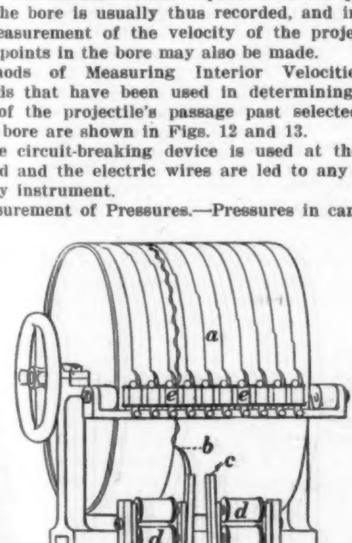


FIG. 9.

directly measured by means of the pressure gage shown in Fig. 14.

In the steel housing, *h*, are assembled the steel piston, *p*, and the copper cylinder, *c*, which is centered by the steel spring or rubber washer, *w*. The housing is closed by the screw plug, *s*. A small copper obturating cup, *o*, prevents the entrance of gas past the piston, and a copper washer performs the same office at the joint between the housing and the closing plug. A series of grooves, *a*, called *air packing*, is sometimes cut near the bottom of the piston, and assists in obturation in the case of a defect in the copper cup. Any gas that may pass the cup has its tension materially reduced by expansion into the successive grooves.

In another form of gage the housing is threaded on the exterior and the gage is screwed into a socket provided in the head of the breech block.

The gage is placed in the gun behind the powder charge, or inserted in its socket in the breech block.

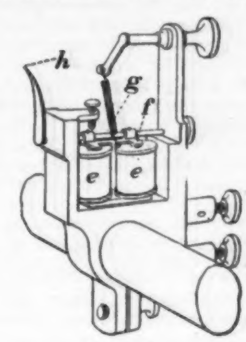


FIG. 10.

When the gun is fired the pressure of the powder gases is exerted against the end of the piston and the copper cylinder is compressed. The compression is manifestly due to the maximum pressure exerted in the gun. The length of the cylinder is measured both before and after firing, and the compression due to the pressure is determined. With the compression thus obtained, the pressure per square inch that produced it is read at once from a "tarage" table previously constructed.

The Tarage Table.—The copper cylinders are cut in half-inch lengths from rods very uniformly rolled and carefully annealed. The compression of the cylinders under different loads is determined in a static pressure machine. It is assumed that the compression obtained in firing is due to a load on the piston of the pressure gage equal to the load that produced the same compression in the static machine. The pressure per square inch in the gun may therefore be obtained by dividing the static load that corresponds

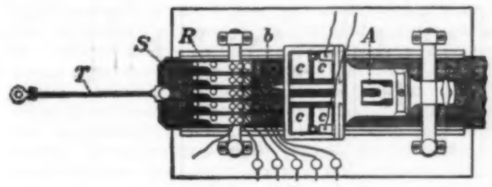


FIG. 11.

to the observed compression by the area of the piston in the pressure gage. Knowing the area of the piston used, the table of compressions and corresponding pressures per square inch is readily constructed from the results obtained in the machine.

The area of piston in cannon gages is 1/10 of a square inch, and in the small arm pressure barrel, 1/30 of a square inch.

Initial Compression.—When the pressure in the gun is high, the compression of the copper is considerable, and the piston acquires an appreciable velocity during the compression. The energy of the piston due to this velocity adds to the compression that would result from the pressure alone, and consequently the measured compression is greater than the compression that corresponds to the true pressure. The energy of the piston may be reduced in two ways—by reducing its weight, and by limiting its travel and accompanying velocity. The piston is made as light as possible consistent with the duty it has to perform. To limit its travel the copper cylinders are initially compressed before using, by a load corresponding to a pressure somewhat less than that expected in the gun. Further compression of the copper will not oc-

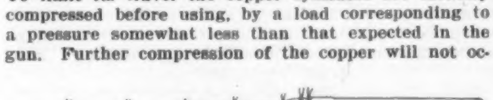


FIG. 12.

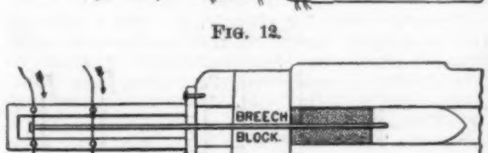


FIG. 13.

cur until the load applied in the gun is close to that used in the initial compression.

The general practice is to use a copper initially compressed by a load corresponding to a pressure about 3,000 pounds less than that expected in the gun. Thus if a pressure of 35,000 pounds is expected, a copper initially compressed by a load corresponding to 32,000 pounds per square inch is used.

Small Arm Pressure Barrel.—In the measurement of pressures in small arms a specially constructed barrel whose bore is the same as that of the rifle barrel is used. The piston of the pressure gage passes through a hole bored through the barrel over the chamber, and a steel housing erected over that part of the barrel serves as an anvil for the copper cylinder.

A hole is bored through the metallic cartridge case to permit the powder gases to act directly on the end of the piston.

The Dynamic Method of Measuring Pressures.—This consists in determining the velocities of the gun in recoil, as by the Sebert velocimeter, or of the shot at different points of the bore. The differences of the velocities divided by the corresponding differences of the times give the accelerations, and the corresponding pressures are obtained by multiplying the accelerations by the mass. A pressure obtained in this manner is evidently only the pressure required to produce the observed acceleration in a body whose mass is that of the gun or of the projectile. That part of the pressure expended in overcoming the friction of the projectile in the bore, in giving rotation to the projectile, and in heating the walls of the gun is neglected. The measured pressure is consequently less than the true pressure exerted in the gun.

Comparison of the Two Methods.—When the same pressure in the bore is measured by the dynamic method and by the pressure gage the result obtained dynamically is usually the greater, and this notwithstanding the fact, as just explained, that the dynamically measured pressure is less than the true pressure. This causes doubt as to the correctness of the pressures recorded by the gage.

In the gun the compression of the copper is effected in a very small fraction of the time required in the static machine that produced the tarage, and as the maximum pressure in the gun is instantly relieved, it is held that the metal of the copper cylinder has not time to flow under this pressure, and consequently that the compression is less than it would be under the same load in the static machine. The pressure as obtained from the compression in the gage is therefore less than the true pressure in the gun.

On the other hand Sarrau, an eminent French investigator, concludes from many experiments that with gunpowder, when the pressure gage is placed in rear of the projectile, the compressions will agree with the tarage. The maximum pressure in the gun is reached in a very short time, but the time is ap-

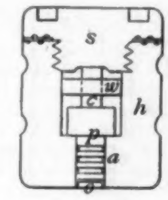


FIG. 14.

preciable. Therefore, the application of the pressure resembles in some degree that of the force producing the tarage. When high explosives are used, or when with gunpowder the pressure gage is placed anywhere in front of the base of the projectile so that the gas strikes it suddenly upon the passage of the projectile, the rate of application of the force is so great that as a general rule the true pressure is measured by the tarage corresponding to half the actual compression of the cylinder.

Though these differences of opinion as to the correctness of the pressure gage exist, the gage itself is in general use. It affords the most convenient method of getting a measure of pressure, and serves to compare the measured pressure with what is known from experience to be a safe pressure in the gun.

MANGANESE IN MANGANESE-BRONZE.

A RECENT controversy has arisen between a manganese-bronze producer and a manufacturer in regard to the term manganese-bronze. The manufacturer found no manganese in the manganese-bronze that was sent to him, hence he considered that the metal was not manganese-bronze.

According to the Brass World, to the uninitiated, such a supposition is quite natural. If a manufacturer received a shipment of tin-plate without any tin, he certainly would not accept it. He would also expect a graphite crucible to contain graphite. It is not a matter of surprise, then, that those who are unfamiliar with alloys should expect to find manganese as an ingredient of manganese-bronze. If it has unsatisfactory properties and is free from manganese, then it is assumed that the absence of the manganese is the cause of it.

It should be noted as a well established fact, that manganese-bronze may be of excellent quality and yet contain no manganese at all. As a usual rule, commercial manganese-bronze ingot contains a very small quantity of manganese, but when melted over once or twice, it oxidizes and disappears.

The object of adding manganese to manganese-bronze is to act as a carrier of iron. Iron is the strengthening ingredient of manganese-bronze and without it the metal would not be satisfactory. It is impossible, however, to introduce the iron directly as it will not alloy with the copper. By first alloying the manganese with the iron, the iron will all chemically combine with the copper. The only function of the manganese, then, is to act as a carrier of the iron into the copper. The

small amount of magnanese that is added for this purpose is oxidized out in a few meltings so that not the slightest trace can be found in the bronze.

INTERNAL STRAINS IN IRON AND STEEL.*

By Henry D. Hibbard.

A noted ordnance engineer once said to a friend, in speaking of the production of great steel guns, "How is it? We design our guns with a factor of safety of eight, and the guns burst." The vague way in which internal stresses and strains in iron and steel are often considered and spoken of makes it worth while to examine their causes and results, how they may be advantageously dealt with, and how when detrimental they may be reduced or kept within harmless proportions. Rankine defines "strain" as a change of form or dimensions of a solid or liquid mass produced by a stress. This definition seems not intended to cover strains due to internal stresses, and it will help us in the present inquiry to consider strain as a tendency to change as well as an actual change of form.

Internal strains in iron and steel are the result of stresses within the mass of the piece, some parts being in tension and some in compression, each part striving to relieve itself from strain and make the piece assume a form in which all parts are at rest. The internal strains we are now to consider are not those due to the stresses of the service which the piece is rendering, but those which originate or at least are contained in the piece itself.

Internal strains reduce the specific gravity of a piece of iron or steel. Consequently, the metal is heaviest when it is in the annealed state. It is common to assume that a piece of steel which has been cold hammered or cold rolled or wire drawn is "more dense" after these operations than it was before, when it is actually lighter. Internal strains accompany if they do not indeed cause inferior resistance of the metal to chemical action. A file broken off, and the broken end immersed in dilute hydrochloric acid, has been found to have lost a greater thickness of metal from the hardest part, at and near the outside, in which the strains are greatest, than from the less hard central portion. The quick corrosion of wire nails and wire fence may possibly be ascribed to the cold-worked condition, and directly or indirectly to the internal strains. The corroding agent more readily enters the mass of the metal, it may be, because of larger intermolecular spaces.

TWO GENERAL CLASSES OF STRAINS.

For the purpose of this paper, internal strains in iron and steel may be divided into two classes, according to the causes which produce them: 1. Those caused by an irregular rate of change in temperature—that is, of heating or cooling. 2. Those caused by cold working or permanent change of shape of the piece under consideration by mechanical means at atmospheric temperatures, or at least at temperatures below that at which the metal is softened.

Internal strains due to irregular heating or cooling are by far the more important of the two classes. Because iron expands when heated and contracts when cooled, and indirectly for other reasons, internal strains, varying in all degrees from harmless to fatal, exist in all pieces of iron and steel. This arises from the fact that all commercial iron and steel is the product of processes involving heat, the strains in most cases being those set up by the more or less irregular rate of cooling. The amount of change in temperature does not affect the strains produced. The rate determines all.

The strains due to irregular cooling, unless chemical changes are involved, are apparently between part and part. Those due to cold working may be considered as between molecule and molecule because of the disarrangement of the molecular formation. The latter results usually in strains between the parts as well. Strains which come under this division of the subject should be considered under two aspects: 1. Those which arise during the continuance of the causes which produce them—that is, temporary strains. 2. Those which remain after their causes have ceased to act—that is, permanent strains. Temporary strains in many cases become permanent, especially when set up during cooling at an irregular rate. The phenomena of permanent strains are, during their formation, the same as of temporary strains.

The following cases will illustrate the two ways in which each kind of strain may result in rupture of the piece. When an ingot of hard steel is placed in a red-hot furnace, and is so ruptured internally by the faster expansion of the exterior, due to the rapid heating it undergoes, that it separates into pieces when forced or rolled, its ruin was caused by strains occurring while the cause, namely, the quick heating, was in operation. This is a typical example of temporary strains in steel. When a boiler plate of soft steel, lying cold on the floor of the shop, cracks suddenly, it is because of strains existing after their cause had ceased its action. This is the usual kind of internal strains occurring in iron and steel, and is the kind chiefly meant in what follows in this part; it is an example of permanent strain. These two instances cited are, it will be understood, extreme cases, in which the piece is ruptured by the intensity of the strains. Strictly speaking, permanent strains are but relatively permanent, since they decrease when the piece is again heated, or through the seasoning or annealing action of time. When strains result in rupture of the piece of metal they are thereby much reduced in amount and otherwise modified.

* From a paper read before American Institute of Mining Engineers.

While strains are unavoidable, they are—except in special cases—undesirable in proportion as they are great. The exceptions arise when the strains increase desirable properties, as, for instance, hardness in hardened steel.

Expansion and contraction of iron and steel by change of temperature, where the new temperature has become uniform throughout the piece or structure, does not set up new permanent strains or materially change those existing between the different parts of the piece or structure, provided the different parts are all of the same kind of metal, or at least of metals having the same coefficients of expansion. In a structure made of metals having different coefficients of expansion rigidly fastened together, a change of temperature is sure to increase or decrease the strains.

The intensity of the strains considered in this part depends on the following determining factors: (1) The rate of change of temperature; (2) the shape of the piece; (3) the bulk or volume of the piece; (4) the elastic limit of the metal; (5) the ductility of the metal; (6) the coefficient of expansion of the metal.

THE RATE OF CHANGE IN TEMPERATURE.

1. The rate of change of temperature is the great governing condition producing or reducing internal strains, both temporary and permanent. The faster the rate, the greater the strains. The amount of change, however great, is unimportant in this connection if the rate be sufficiently slow. The rate depends on the difference between the temperature of the piece of metal and that of its environment, and on the heat conductivity of the metal. The greater the difference in the temperatures mentioned, the greater the strains resulting, and the greater the heat conductivity the less the strains. A poor heat conductor like manganese steel must, if massive, be heated very slowly if dangerous strains are to be avoided.

Extreme cases, in which the rates of change of temperature are the greatest met with in the practical manipulation of iron and steel, are: for rising temperature, when the article is placed cold within the hot heating chamber of a furnace; and for lowering temperature, when it is taken heated from a furnace and plunged into a cooling bath. During a change of temperature strains are set up within the piece, through the differences in expansion and contraction, due to differences of temperature of the parts. These differences are the greater for a given iron or steel article the more rapid the rate of change.

To avoid danger to the piece from this cause, which is the one to which may be directly laid nearly all the actual damage done by strains in iron and steel, one must maintain less difference between the temperature of the article and that of its environment. If the dangerous strains arise in heating the article it must be heated more slowly. The heating chamber or receptacle must not be too much hotter than the article placed therein. In extreme cases, the chamber and the article must be slowly heated together, this procedure being called for, however, only in the heating of bulky articles of very hard iron or steel.

WHERE SLOW COOLING IS ESSENTIAL.

When dangerous strains are liable to arise from too rapid cooling, they may sometimes, as in the case of a cast-iron car wheel, be relieved or reduced in intensity by a slower rate of cooling, the red-hot wheels being piled up in tight soaking pits built in the ground, and allowed to cool very slowly. The lowering of the temperature of both the thick and thin parts is maintained at a rate sufficiently uniform to insure their reaching ordinary atmospheric temperatures at about the same time; the thicker parts do not then continue their contraction after the thinner have ceased theirs, which action, if it took place, would result in strains that might easily be dangerous to the integrity of the wheel, in view of the almost total lack of ductility in the cast iron of which it is made.

Many steel castings may not be allowed to cool in the open, or even in the sand, without danger of spontaneous rupture from internal strains, but must be placed while still hot in a heated receptacle, usually a furnace, and allowed to cool with the furnace at a much slower rate than if in the open air. Steel wheels, as well as the iron car wheels mentioned above, usually require such treatment, though the ductility of the softer grades may admit of its omission. On the other hand, the greater coefficient of expansion of steel tends to set up greater strains than those of the iron wheels.

In special cases, for example, in cutting tools of steel where only the cutting edges demand the rapid change of temperature, some relief, often adequate, is to be afforded by heating only the cutting edges themselves to the hardening heat. Then the remainder of the article will not have to undergo such a rapid change of temperature as if made as hot as the hottest part, and the resulting strains in the tool will be much lessened and perhaps made harmless.

If a piece of cold iron or steel of uniform temperature, in which the strains are the result of cooling, be cooled further, uniformly as to the exterior surface, the strains will be temporarily reduced and may be wholly eliminated during the cooling operation, only to be restored much as before when the temperature of the pieces has again become uniform. Such a piece of steel presents during the further cooling the only exception to the statement that all pieces of cold iron and steel have internal strains. A further practical exception is found in the case of a piece of cold iron or steel which has been cooled from a red heat, at which it is too soft to have strains, at an exceedingly slow rate, as in the case of the car wheel mentioned. When the slow rate of cooling is actually continued to atmospheric temperature the article is practically free from strain.

Spontaneous cracks in cold soft steel are still not wholly explained. When such cracks occur in hard and hardened steels or in cast irons which have practically no ductility they are easier to understand, though even in such cases just what was the "last straw" which caused the rupture is not usually apparent. This is on the assumption that the composition of the steel is suitable, particularly as regards phosphorus and oxygen, which must not be present in too great proportions, and further that the steel was well cast and rolled or forged.

Whether or not in the case of the soft steel boiler plate it was an additional strain due to a slight change in temperature, or vibration from some outside cause, or that the fatigue of the metal under strain progressed more rapidly than the relief of strain due to time, and the operation of what might be called annealing by natural causes, is not clear. It is probably directly due to the last of these possible causes following a lessening of the ductility of the metal through working of the piece at the well-known critical temperature termed the "blue heat." Spontaneous rupture never occurs in an old article of iron or steel, provided, of course, that no new strains have been set up within it.

THE SHAPE OF THE PIECE.

2. The shape of the piece of metal affects strains very greatly when it is heated or cooled. If it be made up of relatively thick and thin parts continuously connected to each other, such as the thin web and thick hub and rim of a car wheel, on changing its temperature strains will be set up within it, not only between the interior and surface portions, but between the thick and thin parts as a whole. In the case of a cast car wheel these latter strains are those which are dangerous, causing the breakage and consequent destruction of the usefulness of the wheel if they be allowed to develop to their fullest extent by allowing the wheel to follow its own rate of cooling in the open.

Large plane surfaces tend to intensity strains due to change of temperature of a piece of iron or steel either from heating, cooling from a high or casting temperature, or quenching. The plane surface, cooling or heating more quickly at its edges than elsewhere, cannot yield to internal tension or compression stresses by change of shape, as such stresses act in straight lines within the piece. Relief may sometimes be afforded by curving or corrugating the surface, as in a casting. But a flat sheet like a saw blade may not admit of this, and then means must be employed to conduct the operation of hardening the teeth, when the strains are set up, so that they will not crack the saw. In the case of a large circular saw blade, partial heating is used, and is effected by protecting the central portion of the sheet with thicker iron plates during the heating and cooling operations. The protected portion is not hardened, and has therefore a lower elastic limit and a higher ductility than the hardened rim, and will thus yield a little without breaking.

THE BULK OR VOLUME OF THE PIECE.

3. The bulk of the piece of metal has great influence on its strains when its temperature is changed because of the distance which heat must be conducted between the surface and interior parts. When the bulk and therefore this distance is relatively great the strains are great in proportion, and when the bulk is small they are less. High conductivity of heat tends to offset great bulk in the strains resulting from a change in temperature.

With a piece of metal of a given contour the strains from either cause may be much reduced by reducing the bulk by means of recesses or slots or other holes properly made in the piece. The quenching operation in particular then causes much less strain. In the case of a large tap this principle is applied by drilling a hole along its axis, which has a double effect. First, it allows the cooling fluid to cool the interior nearly as quickly as the exterior as a whole, and secondly, it reduces the actual thickness of the metal to a fraction, perhaps a third, of what it would be otherwise, and in that way reduces the strains due to bulk.

Solid steel armor plates are sometimes cracked internally by the cooling strains arising from the quenching operation, though the steel is rather soft, with carbon from 0.20 to 0.25 per cent, except the hard face. This may be due to either or both of two causes: 1. When the mass of the armor plate or other piece of iron or steel is so great that the final contraction of the interior portion when cooled may not be compensated for by a reduction of cross-section of the metal (such as occurs when a test piece of ductile metal is pulled apart in the testing machine), then internal cracks may occur from the metal being overstrained, regardless of the ductility of the metal. 2. The ductility of the soft steel of the body of the plate is impaired by the long-continued heating without work during the carbonization by the cementation process of the face, which is to be hard, and for that reason will not endure internal strains as well as its composition would indicate. Holes or recesses not being admissible, though they have been recommended by some, re-forging or annealing to break up the coarse crystalline structure existing in the plate is resorted to, after cementation, in an effort to avoid this defect. Nevertheless, the results are not always as desired.

LAYERS OF SOFT AND HIGH-CARBON STEEL.

It does seem, however, that careful experiment should develop a method for making a large soft steel ingot, with a high-carbon steel layer on one side, which

could be forged into an armor plate, thus avoiding the expensive and harmful cementation process. When an article of iron or steel is liable to crack in service from strains, the danger is sometimes best avoided by making it in two or more pieces. This practically amounts to putting cracks in the thing, but often they may be located so as to cause no trouble. The following example will illustrate: A cast-iron bottom plate, on the center of which was cast a large ingot of steel, was broken the first time used, by the expansion of the central part heated by the molten steel. On making a plate for the purpose of four pieces bolted together no further trouble from this cause resulted.

4. The elastic limit of the metal affects the intensity of the strains, because when it is low it may allow the metal to yield under the stresses which cause strains so as to relieve them in part.

5. Ductility of iron or steel sometimes allows it to yield without fracture under stresses of sufficient magnitude, so that the strains are in some degree lessened. A highly ductile metal rarely or never breaks from internal strains unless extremely massive. A metal supposed to have great ductility may actually have very little, due, perhaps, to ill treatment. The boiler plate mentioned had probably been damaged by working at the black or blue heat, so that its ductility was impaired, and the strains arising from irregular heating and cooling were more than the remaining ductility could allow for, and rupture ensued. The armor plates cited also had their ductility much reduced by the long heating during cementation. When, as in cast iron and hardened high-carbon steel, there is no ductility, and the elastic limit coincides with the ultimate strength, the strains set up in cooling cannot be relieved, and may easily reach an intensity which will cause the piece to crack or break.

HEATING TO RELIEVE STRAIN MUST BE SLOW.

6. The coefficient of expansion, strictly speaking, wholly determines the intensity of the strains arising from irregular rates of change of temperature in metals, for if it became zero such strains would not occur. The greater the rate of expansion the more intense become the strains arising from a given rate of change in temperature.

Heating a piece of iron or steel to any degree below the temperature at which it softens will increase the strains within it in proportion to the rate of heating. Therefore, heating to relieve dangerous strain, which is often resorted to, must be very slowly done, so that the interior is heated nearly as fast as the exterior, or the extra strain due to the more rapid expansion of the exterior parts may cause the rupture it is the purpose of the heating to avoid. By such slow heating something like the seasoning effect of time and slightly higher than atmospheric temperature is given to the piece. This effect may be used on large massive heat-treated articles of high-carbon steel, such as heavy cutters and projectiles, and heavy articles of toughened manganese steel, all of which are in a high state of strain, due to immersion at high temperature in a cooling bath.

The increase of strain due to even slow and moderate heating, as, for instance, to the temperature of boiling water, may be used for testing hard heat-treated objects, such as armor-piercing projectiles, to determine whether or not they are in a dangerous condition, or rather to separate those in danger of spontaneous rupture from those which are not. Without some means for discriminating between them, some of them may lose their points by spontaneous rupture months after they are made and have traveled far.

When a cold massive piece of steel, as an ingot, is to be heated in a furnace, it is a matter of importance to know whether its previous cooling was rapid or slow. If rapid, it may contain so much strain as to be ruptured internally by the heating operation, while if it has been slowly cooled it may, because of smaller internal strains, endure that operation safely. To reduce strains in ingots which are to be cooled to the atmospheric temperature, the rate of cooling should be retarded.

INTERNAL STRAINS CAUSED BY COLD WORKING.

The strains due to cold working iron or steel are the result of molecular displacement and very likely of mere changes in the intermolecular spaces, but the theory of the matter we may for the present leave out of consideration. The phenomena occurring with these strains include higher tensile strength, higher elastic limit, greater hardness, less ductility, and lower specific gravity. Strains are an unavoidable accompaniment of cold working iron and steel. Those due to cold rolling or wire drawing purposely applied have often useful effects when properly taken advantage of, while harmful or undesirable effects may be avoided by reducing them by annealing or other proper heat treatment. When the pieces of metal so cold worked are not large and the ductility considerable, there is no danger of spontaneous rupture. The cold working may, indeed, be continued so as to cause dangerous strains if they be not relieved by heating. The service of larger pieces may be such that they are subjected to cold working, as in the case of a die ring for a centrifugal ore-grinding machine, which will cause flow of the metal with resulting strains, and may distort the piece or even tear it apart or break it.

Something like spontaneous rupture is met with in cold rolled or cold drawn shafting when the cold working of the surface portions has so extended them that the interior is strained beyond its strength and thereby ruptured at intervals across the shaft. In that case, when the outer portions are turned off, the bar may drop apart.

USEFUL COLD WORKING STRAINS.

The beneficial effects of strains due to cold working come from the higher tensile strength and elastic limit of the metal. Drawn or cold rolled shafting is much stronger per unit of cross-section than before the cold working, and wire may be made whose ultimate strength is increased several times by the strains set up in the drawing operation. Wire drawing strains give to some varieties of spring wire the greater part of their springiness.

The increased strength of iron and steel wire due to the strains of cold working is made useful in many ways. In the wire cables of suspension bridges it is relied upon and figured in as part of the tensile strength of the wire. In wire for piano strings and for deep-sea sounding, tensile strengths of over 400,000 pounds per square inch have been attained, the greater part of which is due to the internal strains set up in the wire-drawing process.

The effect of seasoning or annealing by time on cold-worked iron or steel, such as wire, is probably not known, but is very likely an appreciable amount, which, as in bridge wire, may reach important proportions with the lapse of decades.

Strains in cold-worked iron or steel may be detrimental in a way. A piece of straight cold-drawn shafting, if machined, as, for instance, in key-seating or in turning, is very liable to be not straight after the machining, as cutting away a part of the strained metal removes part of the stresses, and those remaining cause the resultant effect to be different from what it was, and the new adjustment necessary is found in a new shape of the piece.

The modifications and removal of strains due to cold working by heating for long or short periods of time, one or more times, to temperatures below redness requires investigation. By these temperatures is meant those all the way down to atmospheric, and especially those from 212 to 408 degrees F., the latter being the temperature at which a faint straw color is given to steel of a certain composition. Removal of dangerous strains by subjection to heat not great enough to discolor the surface of the metal would be a good thing in many ways, if feasible. A cold-worked piece of shafting, which will break off in the lathe when the outer skin is removed, might perhaps be practically cured by such heating between the rolling or drawing operations.

In the specifications for wire for a great suspension bridge, the wire as drawn must have a tensile strength of 215,000 pounds per square inch, and after galvanizing must have a tensile strength of 200,000 pounds per square inch. This decrease of 15,000 pounds per square inch is the loss of strength due to removal of strains by heating the wire for a brief period to the galvanizing temperature, or, say, to 800 deg. F. If the heating even at that temperature were long continued, a much larger loss of tensile strength would no doubt result.

THE SEASONING EFFECT OF TIME.

Many believe that there is a reduction of strain in iron and steel by the seasoning effect of time. Old cast-iron cannon, which had given the normal amount of service, were said to have had their strength restored by years of rest. The strains in such cannon were, it is true, the result of service stresses, but such strains in this case are analogous to those produced by cold working, and especially as far as they are affected by annealing by time. In the case of an article of hardened steel, seasoning or annealing by time is held to relieve strains, with the result that the piece is freed from danger of spontaneous fracture or change of shape after being finished, while if unhardened, its strength and ductility are increased by such seasoning. In cold-worked steel the strength will probably decrease in time, as will the elastic limit, while the ductility will increase.

It is probable that such effect as is produced by time upon a piece of iron or steel is chiefly the result of alternate heating and cooling within the limits of the daily range of temperature, but there is evidence indicating at least that seasoning is effected by time alone, whether or not the temperature of the piece is subject to change.

Consideration of the question of seasoning by time brings up the very interesting one previously alluded to, concerning which we are as much or more in the dark, which is that of annealing iron and steel at low temperatures; that is, in the first phase, at not higher than 212 deg. F.; in the second phase, between 212 deg. and the lowest temperature at which steel will be given the faintest straw color, about 408 deg.; and in the third, at temperatures between this and red heat. The temperatures giving steel the tempering colors, straw, yellow, blue, etc., vary for different grades of steel, and therefore cannot be stated exactly for steels as a whole. There is much to be learned in these fields, and the second of the three mentioned seems especially to hold out hope of practical benefit to mankind from applications of its laws. We need to know the effect on each kind of steel object in every condition of size, shape, composition and treatment, of time, temperature, and fluctuations of temperature within the limits named.

CHEMICAL CHANGES AND STRAINS.

Annealing by time may be expected to act in a different way on cold-worked steel in which the strains may be the result of disturbed molecular arrangements, from that on hardened steel, in which the strains result in great part if indirectly from the chemical constitution of the steel. Perhaps it can be determined just how much of the hardness of hardened steel is due to chemical change and how much to strain. If there is no chemical change in heating hardened high-carbon steel to temperatures not higher than the blue color, or even higher, say, to 800 deg. F., then it would appear that any hardening or increase of tensile strength or decrease of ductility which is removed by heating, short or continued, to temperatures not above the blue or the higher degree mentioned, is due to the strains in the piece. The properties due to chemical constitution will then be permanent in the absence of high heat, while those due to strain may fade in time. Internal strains, when in moderate degrees, may either increase or decrease the tensile strength of steel, as shown by many tests of steel in which annealed bars sometimes show higher, but usually lower, tensile strength than the unannealed.

That strains in hardened steel are of a quite different nature from those in cold-worked steel may be shown by the attraction of a magnet. A piece of hardened steel with and without intense strains acts very differently from a piece of wire-drawn steel with and without strains when its attraction for or by a magnet is measured. A file in a hardened condition, which gave a pull of 12 ounces with a common horseshoe magnet, gave, after being heated to the blue heat, a pull of 27 ounces, and after being heated red hot and slowly cooled, 31 ounces. The magnet gave, on its keeper, a net pull of 43 ounces. Tenpenny wire nails have, with the same magnet, an average pull of 27 ounces, while similar nails, heated to redness and slowly cooled, an average pull of 24 ounces. In the nails the strains seemed to have no effect in reducing the amount of the pull, but, if anything, to increase it. Still, the determination was made by crude means, and cannot be accepted as doing more than indicate the effect of the cold working on this property. The apparatus consisted of a small spring balance, the magnet, and pieces under examination.

In the case of the file, the question is more complex. If the carbon is not changed in chemical condition by heating to the blue heat, as has been maintained, then the great increase in the susceptibility to attraction by a magnet must apparently be laid to the elimination of strains. If not, then to an allotropic modification of the iron itself.

THE USE OF FULMINATE OF GOLD IN ELECTROPLATING.

The use of fulminate of gold in making up a gold-plating solution seems to have originated with Roseleur, to whom we owe so much in laying the cornerstone of the art of electroplating. While the fulminate is extensively used in certain sections, it is unknown in others and many platers have never heard of it. Those who use the fulminate, however, turn out excellent work and are believers in it. Those who use the chloride of gold for directly making the bath have usually never tried the fulminate.

Fulminate of gold is made by precipitating a weak solution of chloride of gold by ammonia. The precipitation is carried out with the hot solution. The fulminate of gold separates out and settles down to the bottom of the vessel. The clear solution is poured off and hot water added and the whole stirred. After settling, the clear liquid is again poured off and this is repeated until all impurities are washed out. *The fulminate of gold must not be allowed to dry or it will explode.* While wet, however, it is harmless. After thoroughly washing, it is dissolved in cyanide in the regular manner. The bath is then used in the same manner as the chloride of gold bath.

The advantage of the fulminate of gold lies in the brightness and luster of the deposit. It is for this reason that it is used. The fact that commercial gold is not pure is, perhaps, not widely known. It rarely runs over 997 parts per 1,000 in fineness. The other three parts are silver, copper, zinc, and other metals. Silver and copper, however, are the principal impurities.

When such commercial gold is dissolved in aqua-regia, all of the copper goes into solution and a little of the silver (chloride of silver is not entirely insoluble in muriatic acid) and instead of pure chloride of gold, one containing a little silver and copper is produced. It is the presence of silver and copper that injures a gold bath and prevents it from producing a bright deposit of a rich color. It is this slight amount of impurity that determines the character of a gold deposit. If a gold bath is made from chloride of gold the chances of doing satisfactory gilding are not as good as they are when the fulminate of gold is used.

The advantage of the fulminate of gold lies in the fact that both the chloride of copper and chloride of silver are soluble in ammonia. When, therefore, the chloride of gold is precipitated with ammonia, the silver and copper go into solution and are easily washed out, and only the pure fulminate of gold is left. It is this fact alone that renders the use of fulminate of gold so satisfactory.—Brass World.

It appears probable that one gramme of radium diminishes in weight by about half a milligramme per annum; hence, if the funds of some society admitted of the imprisonment of some definite mass of radium, our successors a hundred years hence would, even if they possessed only the apparatus now at our disposal, be able to determine its loss with sufficient accuracy to enable them to verify the truth of the conclusions arrived at by the physicist of to-day, while the investigation of the radio-activity of the residue would possibly throw light on problems now awaiting solution.

WORK OF THE RECLAMATION SERVICE.

ALTHOUGH the general public is gradually becoming more familiar with the work of the Reclamation Service, little is known concerning the details of this great undertaking outside of the districts directly affected thereby. The accompanying illustrations show a few of the many phases of the work, and demonstrate the tremendous difficulties which have been frequently encountered and overcome. First among these is the question of transportation, for the actual work is usually of necessity conducted at locations almost inaccessible by rail, and in which even wagon roads had to be built at great labor and expense. For instance, in the Salt River project the forty-odd miles over which materials had to be laboriously carted so greatly increased the expense of the latter that the government was obliged to construct its own cement mills on the ground, the raw material, fortunately, being at hand. In almost every case it was necessary to build roads, bridges, canals, and hydraulic or other power plants before the actual work could be begun.

The Reclamation Service is the outgrowth of the explorations of Major J. W. Powell throughout the arid West, reported to Congress in his book "Lands of the Arid Region." For more than a decade after this report was published, Major Powell continued the agitation for governmental action, and in 1888 he, as director of the Geological Survey, was authorized to investigate the extent to which the arid region might be reclaimed by irrigation. In 1894 Congress made a specific appropriation for gaging streams, and work in this direction was extended from time to time, until a large amount of general information was available. The reclamation law went into effect in 1902, and at that time there existed a small corps of engineers trained through years of practical experience, which became the nucleus of the Reclamation Service, the latter being organized for administrative purposes as a part of the Geological Survey. The operations of the Reclamation Service as provided by the Act of June 17, 1902, relate to examinations and surveys for irrigation works and the construction of these after their feasibility has been determined.

Much impatience has naturally been expressed at the slowness with which the reclamation fund is being expended. However, the works to be built by the government must be permanent in character and designed with reference to complete development, and they are in striking contrast with those built by private enterprise, since the latter are largely temporary in character and often constructed with the minimum amount of capital, their projectors having in mind gradual renewal and increase. The government works, on the other hand, are designed to cover all of the land that can be developed in that locality, and each structure must be as nearly permanent as stone, concrete, or steel can make it, while on the other hand money must not be wasted by building them of excessive size or by giving them a strength not demanded by probable conditions.

The following are the principal projects now under consideration:

State.	Project.	Acres irrigable.
Arizona	Salt River*	160,000
California	Yuma	130,000
Colorado	Gunnison	125,000
Idaho	Minidoka	130,000
Montana	Milk River	60,000
Nebraska	North Platte	100,000
Nevada	Truckee*	150,000
New Mexico	Hondo	10,000
North Dakota	Fort Buford	66,000
Oregon	Malheur	90,000
South Dakota	Belle Fourche	85,000
Utah	Utah Lake	60,000
Washington	Palouse River	100,000
Wyoming	Shoshone	175,000

In addition to the principal projects above listed, reconnaissance surveys are being carried on in each of sixteen States and Territories and alternative projects are also being examined with a view to construction, if the principal projects are, for any reason, found to be impracticable.

The Salt River project of Arizona involves the construction of a dam—the Roosevelt dam—240 feet high, for the storage of 1,100,000 acre-feet of water, and of power plants for pumping water for irrigation in the lower valley. The estimated cost of the dam and power plants will be about $3,200,000. The dam site is on Salt River, about 70 miles above Phoenix, and immediately below the mouth of Tonto Creek. Water stored at this point will be turned down Salt River and utilized on 160,000 to 200,000 acres of land in the vicinity of Phoenix. In addition to this it is estimated that by developing the flow available along the river, and using it for pumping, an area amounting to nearly 60,000 acres can be added to the irrigated district in Salt River Valley. The power developed along the river would be transmitted to sub-stations properly located, and redistributed at a lower voltage to pumping stations so placed as properly to furnish water for irrigation.

At the point selected for the erection of the Roosevelt dam a natural site is afforded by a canyon formation 200 feet wide at the base, and increasing to 400 feet in width at the top of the cliffs. By the construction of a barrier of the dimensions proposed a reservoir will be formed about 18 miles in length and averaging 4 miles in width, far exceeding the largest Nile reservoir in the volume of water contained. The dam from foundation to crest will be at least 240 feet in height and will range in thickness from 165 feet at the bottom to 16 feet at the top, the latter dimensions being sufficient to permit providing a highway for vehicles. As yet mainly the preliminary details of the work have been carried out, but these are of no mean importance in themselves. Owing to the character of the country it was necessary to build nearly 100 miles of roads, some of the highways being cut through bluffs ranging from 50 to 75 feet in height. The immense amount of rock cutting, the quantity of cement needed, the elaborate concrete work, rendered necessary the construction of a large cement mill, several concrete mixing plants at various points, as well as smaller industries. Owing to the difficulty in securing fuel and the expense of installing steam power, it was necessary to construct an elaborate 20-mile canal to provide the hydraulic electric power requisite to drive all the mechanism and for illumination, as the work on the project will be carried on day and night.

The Gunnison or Uncompahgre Valley project of western Colorado draws the water supply from Gunnison and Uncompahgre rivers. The water will be

TRUCKEE-CARSON PROJECT. WEST PORTAL OF THE TUNNEL ON THE TRUCKEE CANAL AT DIVISION 2.

TRUCKEE-CARSON PROJECT. A TEMPORARY DAM FOR DIVERTING THE TRUCKEE RIVER INTO A FLUME DURING THE CONSTRUCTION OF HEADWORKS.

TRUCKEE-CARSON PROJECT. THE CONCRETE LINING ON A FINISHED PORTION OF THE CANAL.

TRUCKEE-CARSON PROJECT. EARTH EMBANKMENTS ALONG THE CANAL.

WORK OF THE RECLAMATION SERVICE.

* Partially completed.

taken from the former by means of a six-mile tunnel, beginning in the Grand Canyon of the Gunnison, and ending in Uncompahgre Valley a few miles northeast of the town of Montrose, in Montrose County. From the lower portion of the tunnel, the water will be taken around the edge of the valley for the purpose of irrigating about 125,000 acres of land, which are in the vicinity of the towns of Montrose and Delta, in the counties of those names. By 1904 the topographic survey and the location surveys, the latter requiring the most delicate instrumental work, were finished, and work on the tunnel commenced. This will be approximately 30,000 feet in length and 10½ by 11½ feet in cross section, with a fall of 2 feet in 1,000, and will have a carrying capacity of 1,300 second-feet. It is to be lined throughout, the lining varying with the different classes of rock passed through. The cost is expected to be about a million dollars. A number of canals is included in the proposed system. One, capable of carrying approximately 1,300 second-feet from the Gunnison tunnel to Uncompahgre River, is to be completed in one year from the time of commencing work, with a total cost of the excavation of about $80,000. A second canal is to convey water from the east end of Gunnison tunnel, or from some point on Uncompahgre River, to irrigate the land in the eastern portion of the Uncompahgre Valley. A third canal, to be about 40 miles in length, is for the purpose of conveying water from the Uncompahgre River in a northwesterly direction to the northwestern portion of the district to be irrigated. A large part of the necessary highways has been constructed, much of the road building being carried out with great difficulty. Furthermore, a complete telephone system has been built, for this will be needed not only during the period of construction, but also throughout the future for the maintenance of the irrigation system.

The principal water supply for western Nevada comes from the mountains of California near the western boundary of the State, the principal streams being the Truckee, Carson, and Walker rivers. These converge toward the desert lands and disappear in sinks or lakes at altitudes of about 3,900 feet. Around these sinks are broad stretches of desert land, much of it of excellent quality when watered. The Truckee-Carson project comprises a number of reservoir sites on the head waters of Truckee and Carson rivers. These sites have been surveyed and the localities have been examined for opportunities for diverting the water. The project includes the use of Lake Tahoe as a storage reservoir, a comparatively simple undertaking from an engineering standpoint, but owing to legal difficulties it has not been deemed wise to begin at the upper end of the river. The waters of Truckee River are used for the irrigation of lands in the vicinity of Reno. Below these lands the river flows through a narrow canyon and then turns to the north, its waters being lost in Pyramid and Winnemucca lakes. In this lower canyon is to be built a canal taking out the flood and excess waters of the river which would otherwise be lost in the lakes and carrying them southeastward to a reservoir site on the lower part of Carson River, in which, at the same time, the excess waters of the latter stream can also be used. From this reservoir distributing canals are to be built to cover several hundred thousand acres of land near Carson Sink. On this project all the survey work has been completed. The three divisions of the main canal and the diamond drilling for the examination of bedrock at the lower Carson dam site have been completed. About fifty miles of main distributing canals have been dug, and the construction of the diversion dam and head works of the main distributing canals—for the Carson River—are well under way, as is likewise the construction of highway bridges, falls, head-gates, culverts, and spillways for the main distributing canals. The cost of the diversion canal will be about $1,100,000, while the branches will cost about half as much more.

SHOSHONE PROJECT. THE CANYON JUST BELOW THE DAM SITE.

SHOSHONE PROJECT. CANYON ROAD ALONG THE CLIFF, SHOWING THE CHARACTER OF THE ROAD BUILDING NECESSARY.

The Shoshone Project of Wyoming contemplates the storage and diversion of a portion of the surplus water of the Shoshone River for the reclamation of public land on the north side of the river extending from Shoshone Canyon for a distance of about fifty miles and covering an area of approximately 280,000 acres. At the head of Shoshone Canyon a dam of concrete masonry, arched in plan, will be constructed. The dam site is 75 feet wide on the bottom of the channel and 200 feet wide at an elevation of 240 feet, the proposed height of the dam above the river bed. The walls of the canyon at the site are granite. A dam of the above height will give a storage capacity of 456,000 acre-feet above the intake of the outlet tunnel. A spillway 250 feet in length and connecting with a tunnel through the granite will be constructed for the discharge of surplus flood water. The survey work for this project has been completed and the preliminary operations are well under way. These include borings for examination, construction of highway and telephone systems, laying of conduits, and the building of working quarters and shops.

UNCOMPAHGRE PROJECT. A PART OF THE COMPLETED TUNNEL ROAD, SHOWING SOME OF THE DIFFICULTIES OF ROAD CONSTRUCTION.

WORK OF THE RECLAMATION SERVICE.

The few details, given above, of four of the more prominent irrigation projects undertaken by the Re-

clamation Service, will serve to acquaint the reader with the work which the government has been carrying on. In the future we hope from time to time to publish articles dealing with these interesting undertakings in greater detail.

We are indebted to the Annual Report of the Reclamation Service, F. H. Newell, chief engineer, for many of the facts contained in the above article and for the illustrations herewith.

SOME FUNDAMENTAL CHARACTERISTICS OF MERCURY VAPOR APPARATUS.*

By Percy H. Thomas.

INTRODUCTORY.

The characteristic of the type of mercury vacuum apparatus, invented and developed by Mr. Peter Cooper Hewitt, which distinguishes it most clearly from other forms of vacuum tubes, is its power of passing a comparatively large continuous current with a constant and comparatively insignificant voltage loss. There are, of course, other important features of this mercury vapor apparatus characteristic to it, such as the negative electrode starting resistance; the disintegrating, reconstructing negative electrode, etc.

It is the object of the present paper to discuss a number of the more prominent fundamental characteristics of mercury vapor apparatus, and their reactions on the related electric circuits; and further to suggest a conception of the nature of these phenomena which shall be consistent with the latest theory of electricity. A certain amount of repetition of information already published will be unavoidable.

ELECTRICAL CHARACTERISTICS OF THE CURRENT PATH IN THE VACUUM.

Current passing through the vacuum space of the mercury vapor apparatus experiences a loss of voltage, the numerical value of which tends to remain constant independently of the current strength, except with small currents; for example, currents less than one or two amperes. Although this voltage loss, or drop, is practically independent of the current strength, still it is not of the nature of the counter electro-motive force of a storage battery or motor, which latter are capable of delivering current in a reverse direction on the removal of the supply electromotive force. Neither is it equivalent to an ohmic resistance; it is a voltage loss.

This loss is the sum of three other losses, more or less different in character; that is, the vapor loss, the positive electrode loss, and negative electrode losses.

Vapor.—1. The voltage loss in the vapor increases with increase of vapor pressure, and more or less closely in proportion to this pressure; consequently, since the mercury vapor is saturated and its pressure depends directly upon the temperature of the mercury electrode, the vapor voltage loss is more or less proportional also to the temperature of the mercury electrode or electrodes.

2. The voltage loss depends upon the chemical composition of the vapor; that is, it will be different with oxygen, hydrogen, and air, even at the same pressure; and all of these give a much greater loss than mercury, which is one of the great advantages in the use of the latter.

3. The voltage loss is directly proportional to the length of the vapor.

4. The voltage loss is inversely proportional to the diameter of the vapor path, but not, as might be supposed, inversely as the area of the path.

5. The voltage loss is nearly independent of the current strength, but varies slightly in a direction opposite to the current.

Positive Electrode.—The loss of voltage which occurs at the positive electrode is practically independent of the current strength. The energy represented by this voltage appears as heat at the surface of the electrode. The material of the solid positive electrode seems to have no appreciable direct effect on the volts lost, but a mercury positive, except when perfectly cold, has a loss some volts higher than the solid, probably because of a layer of comparatively dense vapor produced at its surface by the current. This is usually to the disadvantage of the mercury electrode. As the watts energy liberated in the form of heat at the positive electrodes in a commercial apparatus may be quite considerable, the solid positive electrodes have a further advantage over mercury in that they will become heated during operation, and radiate a considerable portion of the heat developed on them, as heat is radiated from a hot coal. This puts no burden on the cooling power of the bulb itself, while mercury positive electrodes will be kept cool by the evaporation of the mercury and additional vapor must be condensed by the bulb. The voltage loss on the positive electrodes is usually found to vary a good deal, but not on account of current variation. Its minimum value is about five volts. Apparently on account of an accumulation at this electrode of a certain amount of some foreign gas, such as air, which has already been stated to have a higher resistance than mercury vapor, the positive electrode loss appears often more than five volts. The loss is practically independent of the temperature of a solid positive electrode.

Negative Electrode.—During normal operation there is also a voltage loss at the negative electrode, practically independent of the current. In a mercury electrode this loss is probably about four volts. It is practically independent of temperature and physical form.

This loss of voltage during operation must be distinguished from the resistance to starting, residing at the negative electrode and usually called the negative electrode starting resistance, or, more briefly, the negative electrode resistance.

The current enters the negative electrode through a very clearly defined small, bright area, or "spot," even on very large electrodes, which normally flits about rapidly over the whole surface when not subjected to the influence of a magnetic field. When, however, a magnet is brought into the neighborhood, the electrode spot is driven to one side as far as the edge of the electrode. By providing an amalgamated metallic body at the surface of the electrode, the negative electrode spot may be caused, under some conditions, to rest quietly on the surface at the junction of the mercury and the solid material.

The negative electrode spot causes a violent agitation on the surface of the mercury and acts as though it exerted a pressure downward, making a depression on the surface. There is, at the same time, a very rapid evaporation of mercury at this point, which seems to be an essential part of the transfer of the current from the vacuum space to the electrode proper. At the same time that the negative spot is vaporizing mercury, it is also heating the electrode itself, which finally becomes so hot as to cause further vaporization. The evaporated mercury is cooled and condensed by contact with the bulb, on the inside of which it collects in drops. The drops grow larger and finally run down into the electrode, tending to cool it.

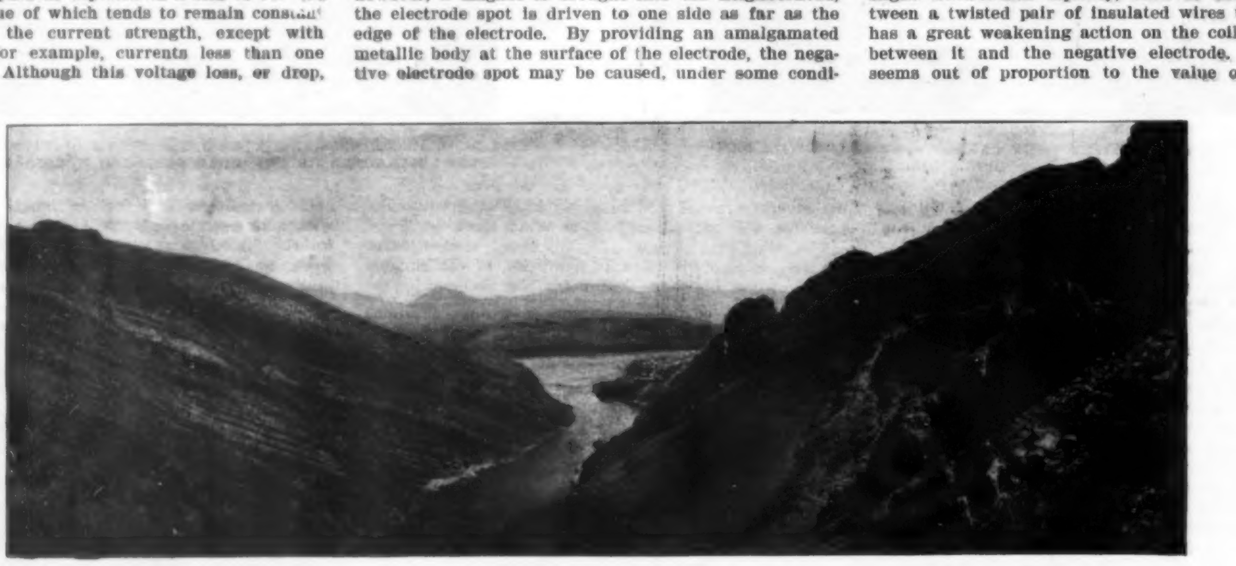
Thus by the passage of current, the negative electrode is heated and mercury evaporated; and further, the vapor itself and the positive electrode are heated. Since the coolest surface in contact with the vapor is the bulb, the vapor condenses on its surface, so that the heat which was abstracted from the mercury electrode by evaporation is delivered to the bulb by condensation. There is in addition some heat radiated directly from the positive electrode when this is of solid material. As there is a best pressure for the mercury vapor in the operation of the apparatus, it is evident that there must be a definite relation between the heat generated and the heat radiated or dissipated by the bulb. In mercury vapor lamps this fact leads to the use of the so-called "condensing chamber," for the light-giving tube alone has not, in the sizes used in practice, sufficient cooling surface, and, furthermore, it is preferable that the condensation shall not occur where it can obstruct the passage of light. In converters the main object is to get as much cooling surface as possible with the shortest practicable vapor path.

The operating negative electrode when the current does not exceed three or four amperes, and the temperature is comparatively low, has a remarkable characteristic in that it experiences at irregular intervals an extremely sudden and abrupt return of the negative electrode starting resistance. This may occur in any degree of severity and at any instant. The tendency, however, lasts but for the briefest instant of time, and has little or no effect on an ammeter measuring the current in the apparatus. As could be expected in view of this behavior, it is desirable to provide a mercury vapor apparatus using small currents, such for example as the 3.5-ampere lamp, with special means for overpowering this momentary increase of resistance. The well-known choke-coil (properly called a sustaining coil) used in connection with Mr. Hewitt's lamps, serves this purpose. It is evident that when once the current has been established in the coil, any action tending to stop the current is resisted by the energy stored in the coil, so that by making the coil large enough, this resistance, which exists only the briefest instant of time, will be entirely overcome. This tendency practically disappears with currents over four or five amperes, and also when the negative electrode is very hot. It is most severe on a cold negative and on a small current. With one ampere on a cold negative it is very difficult to secure steady operation of the negative electrode. This tendency is, to a certain extent, cumulative; that is to say, a certain choke-coil will run the lamp a few seconds, a large coil a few minutes, a still larger coil an hour, while perhaps a still larger coil will be necessary for continuous operation. It occurs absolutely independently of any variation in the supply voltage.

Its most unexpected feature is its extreme abruptness, probably at least of the order of one one-hundred-thousandth part of a second. Of course, only choke-coils with open magnetic circuits can respond quickly enough to be of service in counteracting this impulse. As a natural result of the extreme abruptness of this action, it has been found that even a very slight electrostatic capacity, such as the capacity between a twisted pair of insulated wires ten feet long, has a great weakening action on the coil if connected between it and the negative electrode. This result seems out of proportion to the value of the energy stored in the capacity to the energy stored in the choke-coil. Presumably the brief instant required for the instantaneous charging of this small capacity which must be accomplished before the choke-coil can supply voltage to the electrode, is sufficient to allow the negative electrode resistance to be established.

STARTING CHARACTERISTICS.

A voltage considerably higher than the normal operating voltage may be required for starting the flow of current through the vacuum. For a tube of definite diameter the difference between the starting and the operating voltages is very small for short lengths of tube, perhaps up to ten diameters. But the operating voltage increases directly as the length, while the starting voltage increases more nearly as the third power of the length, so that for long tubes there is a very considerable increase of voltage required for starting. On the other hand, the starting voltage is lessened by increasing the diameter of the tube. This high starting voltage is partly due to the necessity of establishing a path through the opposing gas, and to vapor molecules initially filling the whole space. Once such a path has been established with a considerable volume of current, a much less voltage will evidently keep it clear. In many types of apparatus it is found convenient to start on an auxiliary positive electrode placed near the negative and transfer the current to the main positive electrode after starting. In this case the starting resistance of the vapor path to the main positive electrode must be overcome before normal operation can be established. In a converter bulb where the distance between the negative and the positive electrodes is comparatively short, no greatly increased voltage is required for starting the current through the vapor path proper. In a lamp tube 45 inches long and 1 inch in diameter, such as is used in one type of commercial lamp, several times the operating voltage may be required for starting the current through the vapor, independent of the negative electrode starting resistance. A high resistance filament connected to the positive electrode and extending into the neighborhood of the negative will reduce



SALT RIVER PROJECT. VIEW FROM A POINT ON THE HIGH-LINE ROAD JUST BELOW THE ROOSEVELT DAM SITE.

WORK OF THE RECLAMATION SERVICE.

* Journal of Electricity, Power and Gas.

this vapor starting resistance by allowing the current to climb up, so to speak.

Positive Electrode.—There appears to be no resistance to starting at the positive electrode other than the normal operating resistance.

Negative Electrode.—The negative electrode starting resistance is too well known to need further description. There are two well known methods of overcoming this starting resistance:

1. By establishing a current through a complete metallic circuit within the vacuum, and breaking this circuit within the vacuum, in which case the original current will continue to flow, since the negative electrode resistance never has a chance to assert itself. This result may be accomplished by having two mercury electrodes which may be brought into contact by tilting the container, or otherwise, or by moving suitable parts from outside by a magnet. This type of starting is one of the most commonly used at the present time.

2. The second method of starting consists in directly applying a high potential with or without the addition of various means for reducing the starting resistance.

This negative electrode starting resistance is a very variable quantity, and ranges from almost nothing to many thousand volts, according to conditions. It is very much greater with a cold electrode, especially a cold mercury electrode. It is dependent upon the form and surroundings of such an electrode, and especially upon the potential or charges on the outside and inside of the insulating walls which confine the electrode. If the negative electrode is provided with a metallic strip, called a starting band, outside the container, and this strip be charged at a potential different from the electrode, the starting resistance is weakened or may be entirely overcome. On the other hand if this band or strip be connected to the negative electrode itself, the negative electrode resistance is rendered more stable since it is protected from charges. This is the principle made use of by Mr. Hewitt in starting some of his lamps, and has been already fully described by him. The interruption of the current in the quick-break switch causes a momentary high potential impulse from the choke-coil, which is applied, both to the starting band in the neighborhood of the negative electrode and to the main positive electrode. The former serves to break down the starting resistance of the negative electrode, and the latter supplies the starting voltage for the vapor path. In this method of starting, a small spark or series of sparks can be seen jumping from the edge of the negative electrode to the inside surface of the glass opposite to the starting band, which surface forms the inside coating of a small condenser, the starting band being the outside coating. This small spark is undoubtedly what overcomes the negative electrode resistance.

PHYSICAL NATURE OF VAPOR CONDUCTION.

It is interesting to speculate as to the nature of the phenomena connected with mercury vapor apparatus, and to endeavor to discover some assumption upon which they can be explained, which shall also be consistent with the best hypothesis as to the nature of electricity. The writer has gradually arrived at a way of looking at these things which explains nearly all of them quite satisfactorily, and it is here described for what it may be worth, with the distinct understanding that it is merely a tentative theory until a sufficiently complete body of information shall be available to prove or disprove it.

We may assume that by electricity is meant a greater or less number of those small particles, described by J. J. Thompson as having a mass of about one one-thousandth part of the hydrogen atom, called electrons. A current of electricity, then, is nothing but a stream of these electrons. Since they move in a direction opposite to the conventional current direction, they are said to carry a negative charge; whether the electrons are electricity or carry charges of electricity is immaterial in this case. When we have a direct current passing through mercury vapor apparatus, we have a continuous stream of electrons passing from the negative to the positive electrode within the vacuum and returning through the external circuit, which must include a source of electromotive force. These electrons are caused to move by the electromotive force of the circuit, which causes an increase of potential (that is, a deficiency of electrons) at the positive, and a decrease of potential (that is, a surplus of electrons) at the negative; or, to put it another way, a static charge is produced on the positive electrode which attracts the electrons, while they are, of course, repelled from a negative charge on the negative electrode. The moving electron, like a moving electric charge, stores energy electromagnetically; that is, has inertia.

These electrons are invisible of themselves and pass with extreme velocity, naturally in straight lines, and where unrestrained tend to spread apart and fill the whole vapor path.

In a mercury vapor apparatus the voltage loss in the vapor itself is supposed to be due largely to the presence of molecules or atoms of gas in the path of the electrons which impede their free motion. Since the greater the number of gas molecules in a given space the greater the pressure, it is natural to suppose that increase of pressure would mean increase of resistance to the electrons. Furthermore, these gas atoms or molecules are agitated and set in vibration in being struck by electrons and are caused to give off both light and heat. The light naturally will be the spectrum light of these particular atoms; that is, the particular color or colors corresponding to the natural period of vibration of this particular kind of atom.

When the pressure is sufficiently high, the electrons, instead of spreading through the whole space, are forced into a narrow stream in the center, and the obstructing molecules are at least partly forced to the outside, to be spectators as it were. This effect can be very easily seen by heating the condensing chamber of a mercury vapor lamp with a flame until the vapor reaches a comparatively high pressure, the current will then "string"; that is, will be confined to a brilliant, thin, sinuous line near the center of the tube.

The varying specific resistance of different gases is easily explained by the differences in the character of the molecules.

The negative electrode is assumed to be the source of the electrons which enter the vapor, and the phenomenon of the negative electrode starting resistance is easily explained; that is, if we imagine the small electrons to be material particles, a considerable force would be required to cause them to break out from inside the liquid mercury surface on account of its surface tension, while when once the flow is established on a large current, it is easy to imagine that either on account of the extreme local heating at the surface of the negative electrode, or the rapid evaporation of mercury into vapor at the negative spot, there should be no opportunity for the formation of a new surface on the mercury which could re-establish the electrode resistance. On the other hand, with small currents it is found that the surface tension is able to re-establish itself in spite of the current, so that with currents of intermediate values it would be expected that at intervals the mercury would be able to re-establish the normal surface when accidentally the conditions should be favorable. Hence the advantage of employing a sustaining coil in connection with apparatus using small currents. The lessening of the negative electrode starting resistance, and the lessening of the importance of the sustaining coil with the heating of the electrode, correspond properly with the corresponding reduction in surface tension.

The normal operating voltage loss at the negative must be connected with the separation of the electron from the mercury atom and the evaporation of mercury.

According to the assumption, it should be noticed that the source of electrons is not the ionization of the gas or vapor within the container as in many other experiments—such as the passing of current through air ionized by X-rays—but is the negative electrode itself; that is, within the vapor space during the flow of current we should find normally no positive ions (which are to be taken as atoms or groups of atoms which have been deprived of one or more electrons), only the electrons drawn out of the negative electrode. Thus it would be possible to pass current through the apparatus, even were it to have a perfect vacuum within. Although the resistance to starting in an apparatus in this condition is very high on account of the extreme surface tension, and on account of the absence of positive ions (as more fully explained in a later paragraph), yet once the apparatus is started, the passage of current is exceptionally easy and no light is obtained. It is actually found that with cold mercury electrodes no light appears with current of over 100 amperes. This is a very interesting point, as it has commonly been supposed that a perfect vacuum is a non-conductor; whereas the truth probably is merely that a perfect vacuum has an extremely high starting resistance, but is a most perfect conductor once current has been established.

The question naturally arises: why the negative electrode resistance does not exist in connection with arcs between electrodes in air at atmospheric pressure? It is possible that the following is the proper explanation: the application of a sufficiently high potential previous to the breaking down of the gap upon a spark-gap in air causes an ionization of the air between the electrodes, the negative electrons being attracted to the positive electrode, and the positive ions to the negative electrode. The negative electrons, of course, enter the positive electrode without difficulty, while the positive ions are stopped at the surface of the negative electrode on account of the negative electrode resistance, and attract electrons from within the metal of this electrode up to the surface. We then have positive and negative charges attracting each other, and separated merely by the surface of this electrode, which causes a tremendous strain and is sufficient to withdraw electrons from the negative electrode to neutralize the positive ions, thus breaking down the negative electrode resistance. According to this theory (there being no ionization of vapor) no positive ions will be formed in the mercury vapor apparatus and no such strain produced on the negative electrode; in other words, the vacuum causes the withdrawal of the positive charge (which tends to start the negative) from the surface of the negative as in the air to the positive electrode with a vacuum; thus very much reducing the strain produced on the negative. Hence, the mercury vapor acts as though it could not be ionized in the same sense as oxygen or nitrogen, which is more or less natural in view of the monatomic nature of mercury vapor, especially at vacuum pressures. This theory beautifully explains the "softening" of X-ray tubes by the production within the vacuum space of a slight amount of gas, which becoming ionized renders the cathode more easily broken down.

X-ray tubes, Crookes tubes, and similar vacuum apparatus cannot operate as the vapor electric apparatus of Mr. Hewitt, for two reasons:

1. Because they are not operated with a supply capable of furnishing enough energy to break down completely the negative electrode resistance and reduce it to a normal running value; and 2, because they are so physically constituted as to destroy themselves if operated with supply apparatus of sufficient energy for operating Cooper Hewitt apparatus.

It should be noted that within the vacuum space of a mercury vapor apparatus are two streams of material; electrons passing from the negative to the positive electrode, and the atoms of mercury vapor passing from the negative electrode spot and other hot mercury surfaces to the cooler parts of the container, where they condense. Both of these streams of particles, though so radically different in character, have the power of sweeping with them atoms and molecules of any gas which may be found within the vacuum space, i. e., any such residual gas tends to collect at the positive electrode, or at the condensing surface of the retainer. In the latter location it is very readily absorbed by the condensing mercury, which explains the fact that some apparatus, originally in slightly imperfect condition, will improve with actual operation. At the positive electrode, however, if sufficient in quantity, this accumulated gas will usually raise the voltage of the apparatus on account of its intrinsically high specific resistance, and may also cause an excessive heating of the electrode.

On account of the general acceptance of the hypothesis that electricity is constituted of or connected with electrons which pass from the negative electrode to the positive electrode in the vapor path, it has been proposed to reverse the convention as to direction of the electric current adopted long ago, before any marked difference between positive and negative had been discovered; viz., the convention that current runs from the carbon to the zinc element of a battery in the external circuit.

We then should say that a positive current is one which passes from the mercury electrode of a vapor lamp to the iron electrode, and an electron would carry a positive charge or be a positive charge according to the particular assumption as to the nature of electricity which might be accepted. Such a change would certainly be highly desirable, except for the great probability of confusion for some time afterward.

(To be continued.)

THE ATKINS DRY PROCESS OF GENERATING ACETYLENE GAS.

By the English Correspondent of Scientific American.

The many disadvantages arising from the employment of the wet process of generating acetylene gas, by the combination of water with the calcium carbide, are so great as to outweigh the favorable characteristics of the system. In the first place, the presence of impurities and moisture in suspension in the gas generated is a source of constant trouble, causing the blocking of the feed pipes and the corrosion of the burners. Then again the pressure and heat of the gas during the chemical reaction are such that in case of large installations, extreme care has to be exercised to avert explosion with the generating receptacle.

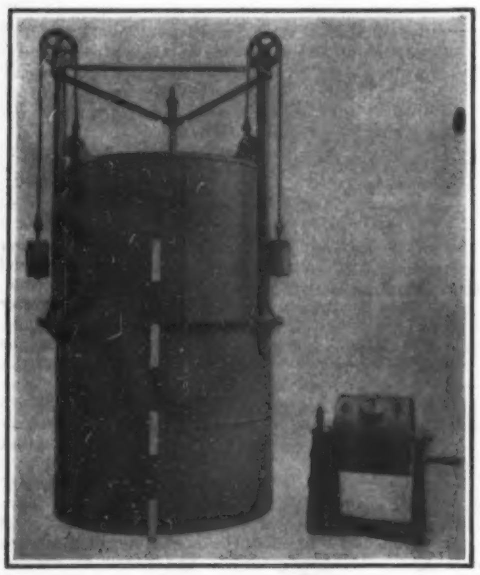
During the past few months an efficient system of generating acetylene by a dry process has been evolved, and the Atkins method, as it is called, is being extensively applied for a variety of purposes such as illuminating, welding, and power in connection with a gas engine specially adapted for operation with this type of fuel. The essential feature of this invention consists in the fact that the gas is produced by mixing the calcium carbide with organic or inorganic substances containing oxygen and hydrogen, and the attraction of the carbide for these two gases is stronger than the hold which the substances used have upon them. Consequently, when the carbide is introduced and agitated with such substances decomposition takes place, and the acetylene is formed. The most suitable inexpensive agent for this chemical reaction that has been discovered is the ordinary soda crystals, so that the system has the advantage of not being a costly one—an important consideration in the development of the method for general commercial purposes.

The necessary plant for carrying out the generation is of a simple nature, comprising only a mixing drum in which to carry out the generating operation, and a reservoir or holder for containing the produced gas. The reservoir is made of steel, and is of sufficient capacity to contain the whole of the gas capable of being produced from the full charge of carbide placed in the generator. The plants are thus designed to meet varying conditions, the generator and the gas holder being made in proportion according to the exigencies of the case. The generating plant comprises a revolving drum mounted on a framing and capable of being revolved in either direction, though two different functions are accomplished according to the direction of the rotation. The drum is built strongly of steel, and the interior is divided into three departments by means of steel diaphragms *A*, *C*, *D* (see accompanying diagram). The first chamber *A* contains the charge of carbide, and the second *B* the soda crystals, the mixing process being carried out in this compartment. The remaining chamber *C* is a filter through which the generated gas passes, and is thereby released of its impurities before entering the storage reservoir. The drum revolves upon a shaft, hollow at one end, and to which it is firmly fixed. The hollow end of the shaft is at the point where it carries the filtering chamber *C*, and is provided with a series of orifices through which the filtered gas passes to the hydraulic seal forming one of the standards to the frame, thence into the gas

holder. The chambers *A* and *C* are provided with hand holes *K*, *J*, through which the carbide and soda are respectively placed in their individual chambers, and through which the residue remaining in the mixing chamber can be removed after generation is completed.

The carbide and soda crystals are charged in equal proportions into the two chambers. On the drum are placed two indicators showing direction of rotation, one being marked "Feed" and the other "Mix." By rotating the drum in the first-named direction, the calcium carbide is delivered from the chamber *A* into the mixing chamber *C* through the ingeniously contrived shoot *B*, which is mounted on the diaphragm dividing plate, inclined at a slight angle and entirely inclosed except on one side. By this arrangement the carbide is only fed into the mixing chamber when the drum is revolved in one direction, i. e. the "feed." By this means it is possible to control the amount of carbide to be associated with the soda; and in order to obtain the maximum amount of gas in the minimum of time, only a small quantity of carbide is fed at a time, the general practice being to revolve the drum once in the "feed" direction, and then to rotate it in the opposite direction.

As before mentioned, no carbide can pass from *A* to *C* when the drum is rotated in the "Mix" direction. Generation commences directly the two substances come into contact; but to expedite and facilitate decomposition, there is a mixing plow *F* suspended from the shaft, and this keeps the contents of the mixing chamber constantly agitated, so that the substances are broken up. As rapidly as the gas is generated it escapes through perforations *M* in the diaphragm wall of the filter chamber *D*, which is filled with a coke filtering medium. Passing through this, any dust or particles of grit in the gas are arrested, and it issues

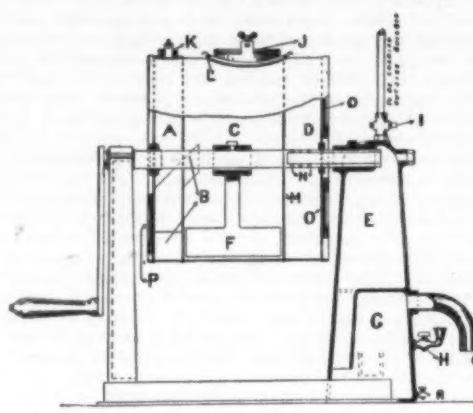


THIS IS A GAS HOLDER OF 100 CUBIC FEET CAPACITY AND GENERATOR USED IN THE MANUFACTURE OF ACETYLENE BY THE DRY PROCESS.

in a pure condition through the perforations *N* in the shaft into the hydraulic seal *E* and *G*, thence through the outlet *Q* into the gas holder. The hydraulic seal is divided into two sections, *E* the upper part, and *G* the lower, and is fitted with a test and filling cock *H* and a drain cock *R*. For the purposes of carrying off the air contained in the drum, and which is displaced by the generated gas, there is an air cock *I*. The plant is of simple design and every section is readily accessible for cleaning, there being manholes in addition to those through which the carbide and soda are charged, to the filter compartment at *O* and the carbide shoot in *A* at *P*. To discharge the residue left within the mixing chamber after generating is completed the screw-down cover *J* is removed, a sack attached by means of the hooks *L* and the drum inverted, the contents being discharged into the bag. The plant is entirely mechanical in its action, and is consequently immune from those inopportune breakdowns to which automatic arrangements, especially in connection with acetylene gas production, are invariably subject.

Owing to the simplicity of the process, skilled labor is not required. In the case of a plant of 250 cubic feet capacity supplying 120 burners, sufficient supply for 24 hours can be produced in less than half an hour. The space occupied by such a plant as this is only 12 feet by 6 feet, of which area the gas-holder occupies the major portion, its diameter being 7 feet 9 inches by 6 feet 6 inches in height. As no liquid of any type is employed in the process, there are no solutions formed liable to act upon or corrode the metal. The heat set up as the result of the chemical action is slight—totally different from the conditions prevailing in the wet process—and the pressure within the drum is very low, the only valve being a small rubber disk capable of resisting a pressure up to a 4-inch column of water, which is equal to a pressure of 2¼ ounces to the square inch.

The resultant gas is of great purity, there being almost imperceptible quantities of phosphor and sulphur charged compounds compared with those present in water-generated gas. All commercial carbide contains as impurities certain quantities of calcic phosphide, and this when acted upon by water is converted into phosphureted hydrogen, which issuing with the acety-



SECTIONAL VIEW OF GENERATOR AND MIXING CHAMBER.

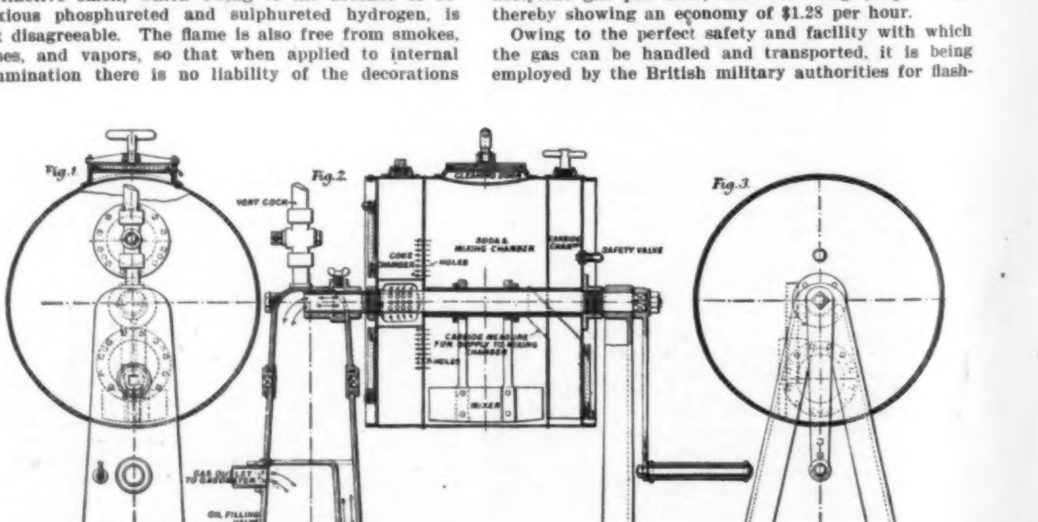
lene not only causes objectionable fumes, but at the same time constitutes a grave source of danger. On the other hand, in generating the acetylene by the dry method, the calcic phosphide is converted into a harmless sodic phosphite and remains in the residue left in the mixing chamber. In like manner the sulphur impurities present in the carbide are not converted into the evil-smelling sulphureted hydrogen, but are similarly fixed in the residue in the form of harmless sulphites of soda. These by-products, it may be pointed out, issue in the form of a bone-dry powder, and can thus be easily dealt with. This residue is perfectly harmless, and if the generation is carried out upon a large scale, a large portion can be rendered commercially valuable. The carbonic acid of the carbonate of soda combines with the calcium and forms chalk, so that the by-products comprise chalk, caustic soda, and lime. The residue does not require treatment of any description nor immersion in water, and this feature, which is one of the most notable in the invention, dispenses with severe restrictions that are imposed in England by the local authorities in respect to consumers of the wet-generated acetylene, since no particles of the carbide are left undecomposed in the residue. The extreme purity of the produced gas may be gathered from the fact that prolonged tests of samples drawn from a gas holder that had been in constant use for over four months were made by a well-known analyst, and it was found that the impurities present comprised sulphur 0.010 milligramme, phosphorus 0.082 milligramme, and ammonia 0.336 milligramme per liter—rather less than one-half per cent.

The "sun gas," so called from the resemblance of its color to sunlight, produced by this process, which is being developed by the Sun Gas Company of Broadway, Westminster, London, though not possessing the powerful nauseating odor of ordinary acetylene, has yet a distinctive smell, which owing to the absence of obnoxious phosphureted and sulphureted hydrogen, is not disagreeable. The flame is also free from smokes, gases, and vapors, so that when applied to internal illumination there is no liability of the decorations and appointments becoming deteriorated in any manner. From the hygienic point of view it is much preferable to ordinary coal gas, while the inhalation of the gas itself is not attended by dangerous results, as it is non-poisonous. The actinic value of the light is high, the blue and violet rays predominating.

The successful perfection of this process has resulted in a decided stimulus in the utilization of acetylene gas for lighting installations for private residences in the country, where gas and electricity are not available, owing to the removal of the severe restrictions imposed by the government upon wet acetylene gas on account of its dangerous explosive qualities. In the latter part of last year a series of elaborate experiments were conducted by the experts of the Home Office, which has the control of all explosives, to determine the safety of the sun gas. For these experiments three calibrated gas holders were coupled together. The first contained pure dry generated acetylene, the second oil gas compressed to 120 pounds pressure, while the third contained a certain mixture of the two gases. Connected to the last named gas holder was a gas compressor placed in an iron tank filled with water and operated by hand. Three carbonic-acid gas cylinders each of 0.5 cubic foot capacity were prepared, fitted with a valve and union connection at one end, and a sparking plug at the other. The points of the sparking plug carried a piece of thin platinum wire round which was wrapped a small charge of guncotton. The cylinders were then charged. First a mixture of dry acetylene and oil gas in the proportion of 40 to 60 was carried from the first two gas holders into the third. One of the cylinders was connected to the submerged compressor, and then well cleansed with the mixed gases. The cylinder was then filled with a charge until the pressure gage showed 200 pounds per square inch. The loaded cylinder was then dropped into a pit 5 feet in depth, and the firing battery, comprising eight dry cells connected with two electric wires 300 feet in length with a galvanometer placed in circuit, connected to the firing plug. The current was then switched on, but although subsequent investigation showed that the guncotton charge had exploded and the platinum wire deflagrated, the gas had not been changed and there were no traces of carbon. A mixture consisting of 50 parts of both the aectylene and oil gas was then inserted into the cylinder at the same pressure and the process repeated, but identical results were achieved.

As a result of the success of these tests, dry acetylene is not admitted within the former explosive acts, but the stipulation only applies to that produced by the Atkins system. Certain conditions, however, are imposed in the interests of public safety, and its admixture with oil gas in certain proportions is permitted. The proportion of acetylene must not exceed 50 parts by volume in every 100 parts of the mixture of acetylene and oil gas; the two gases must be mixed in a vessel before being compressed, and the limit in compression is 150 pounds per square inch. The government concession, however, expressly stipulates that the gas shall be generated by the Atkins dry process. The mixture of the oil and acetylene gases gives complete satisfaction for lighting purposes, and in the Midland counties many of the railroad stations have adopted it with complete success. As compared with coal-gas lighting, the acetylene is much more economical both in consumption and cost. For instance, in one manufactory it was found to be 40 per cent cheaper. Prior to its installation in this instance the building was lighted by 625 burners which consumed 4,375 cubic feet of coal gas per hour, and giving an aggregate illumination of 7,437 candle-power. With the gas costing 75 cents per 1,000 feet, lighting cost $3.28 per hour. With the sun gas system 413 burners were found adequate, the aggregate candle-power being the same. The consumption was only 206 feet of dry acetylene gas per hour, the cost being $2 per hour, thereby showing an economy of $1.28 per hour.

Owing to the perfect safety and facility with which the gas can be handled and transported, it is being employed by the British military authorities for flash-light signaling. In this case the generating plant is the most simple that could be desired, comprising simply a small India-rubber bag into which the carbide and soda are emptied from small cartridges. The bag is then violently shaken in the hand, and in a few seconds sufficient gas is generated for the manipulation of the lamp.



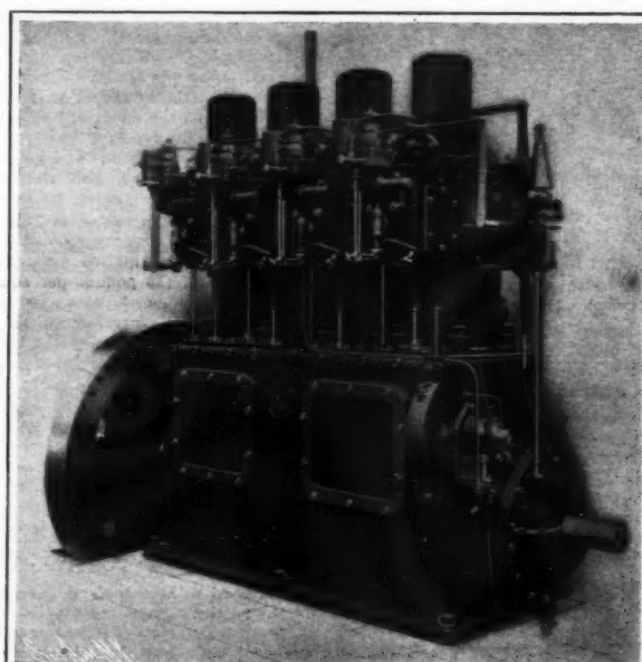
THE GENERATOR USED IN THE MANUFACTURE OF DRY ACETYLENE GAS.

THE 50-HORSE-POWER FOUR-CYLINDER CROSSLEY VERTICAL OIL ENGINE WITH NEW SYSTEM OF GOVERNING.

The utilization of the heavy-oil, internal-combustion engine in the multicylinder type has been attended with many difficulties, necessitating the employment of somewhat complicated mechanism, while the results obtained have not been attended with sufficient satisfaction to encourage the adoption of the type to any great extent. Such engines, when operated either with one or two cylinders, are completely successful; but when the cylinders are increased beyond that limit, several disadvantages seem to develop. Efforts have been made to render the muticylinder engine as satisfactory as the single and twin cylinder varieties, but with only mediocre success. Messrs. Crossley Brothers, Limited, of Manchester, whose practice with the gas engine is so well known, have however evolved a 50-horse-power, four-cylinder engine, in which the difficulties have been successfully surmounted by the employment of a new system of governing which they have developed.

As may be seen from the accompanying illustration, the engine is of the vertical type, the general design being similar to the ordinary gasoline motor. Each of the four cylinders has a bore of 9 inches and a stroke of 12 inches, the 50 brake horse-power being developed at a speed of 300 revolutions per minute.

Each cylinder is fitted with two inlet valves, one for the admittance of the explosive mixture into the combustion chamber, while the other passes air only. In the air passage leading to the air inlet valve to each cylinder is placed a butterfly throttle valve, which is connected to, and operated by, the Crossley new patent governor. When the load on the engine is de-



A 50-HORSE-POWER KEROSENE ENGINE FITTED WITH NEW SYSTEM OF GOVERNING BY AUXILIARY AIR.

creased, the speed of the latter naturally tends to rise. At this moment, however, the governor opens the throttle valve, thereby passing through more air into the cylinder. The vacuum in the cylinder during the suction stroke is thus reduced, with the result that less gaseous mixture is drawn in through its respective inlet valve. Consequently, the power of the successive impulses becomes weaker, the reduction continuing until the engine has resumed its normal speed.

When, however, the load on the engine is increased, the speed of the engine is reduced, and this action causes the governor to close the throttle valve, thus reducing the quota of air and at the same time permitting a richer explosive mixture to be drawn into the combustion chamber. The impulses then increase in power until the engine attains a normal speed. The supplementary air valve is placed directly over the exhaust valve, some little way forward of the mixture inlet valve.

By means of this system of governing, the inventors state that the fluid frictional losses on light loads are reduced instead of increased, as is generally the case. It enables automatic ignition to be effected on all loads with perfect facility, with simple self-heated ignition tubes, since compression is higher on light than on full loads. Owing to the fact that the normal compression pressure is not reduced on light loads, it is always available for overcoming the inertia of the reciprocating parts, and prevents any knock; while, furthermore, the absence of any knock and of any complicated gear enables quietness and smoothness in running under varying loads to be obtained.

The engine is started by compressed air admitted through special valves on each of the two center cylinders, without in any way interfering with the ordinary valves or their gears. All cams and gearing are inclosed. The oil vaporizers are of the internal type, heated by lamps for starting, and afterward maintained at the required temperature by the heat of the ignitions. The liquid fuel flows by gravity to the four mixing valves from a standpipe to which it is delivered by a single pump. Automatic lubrication on the splash principle is employed throughout.

COMBUSTION CHAMBERS IN LOCOMOTIVE BOILERS.

The American Locomotive Company has received orders for seventy large locomotives for the Northern Pacific Railway, in all of which combustion chambers will be used. There are three types of locomotives on order, the Pacific, in which the combustion chamber is 36 inches long and tubes 16 feet 9 inches; the Mikado, with combustion chamber 36 inches long and tubes 16 feet 6 inches; and the Prairie, which has combustion chamber 32 inches long and tubes 13 feet 3 inches.

An experimental locomotive of the Mikado type with combustion chamber and tubes similar to the above has been in service on the Northern Pacific road for 18 months with satisfactory performance.

Combustion chambers 3 feet long were used in large numbers 30 years ago on the Reading Railway in connection with a firebox 8 feet wide projecting over the driving wheels as designed by J. E. Wootten. In these very wide fireboxes the brick arch was replaced by a straight bridge wall across the back end of the combustion chamber. It is not clear just what the function of the combustion chamber is with anthracite coal in very wide fireboxes, having a large volume for the mixture and combustion of gases. Anthracite coal contains 85 per cent fixed carbon and about 5 per cent hydrocarbon. The western bituminous coals on the other hand are rich in volatile matter, containing 35 to 40 per cent, and about the same proportion of fixed carbon. With such a large proportion of volatile matter there would appear to be more reason for the use of the combustion chamber for bituminous coal than anthracite, but heretofore it has never been used for bituminous coal except in an experimental way.

In 1895 the Burlington experimented with a combustion chamber 34 inches long in a locomotive of the Columbia type. In this boiler the front water-leg was straight and at a right angle to the axis of the barrel of the boiler. The water spaces were small and did not have the advantage of the free circulation due to the inclined water-leg of ample width which is used in the Northern Pacific designs. For this reason the firebox side sheets of the Columbia engine were not kept cool and they failed after about one year's service. This experiment was made in connection with a firebox 5 feet long and tubes 12 feet 9 inches long and grate area of 44½ square feet, total heating surface 1,580 square feet.

The combustion chamber was one of the essential features of the Wootten patents, and when the other anthracite roads adopted the wide firebox they left off the combustion chamber not only on account of its patent relations, but because it required a more complicated construction and it was not found necessary for burning fine anthracite with as good economy as fireboxes with combustion chambers. The combustion chamber is simply an extension of the firebox providing additional volume for the mixture and burning of the gases and a slight gain in direct heating surface. This gain is at the sacrifice of about ten times as much heating surface in the tubes. The principal advantage of the combustion chamber is that it places the tubes away from the intense heat of the firebox proper and to some extent prevents them from leaking. It also renders it possible to get at all the tubes for rolling or calking without destroying or disturbing the brick arch. It has not been found that the combustion chamber has contributed to economical coal burning and no advantage is claimed for it in that respect. When it is found desirable to protect the tubes by moving them further from the firebox proper, and making them shorter, the vital question must arise as to what this distance shall be and how much tube heating surface can be sacrificed.

In Mr. Van Alstyne's paper before the Northwest Railway Club, January 9, 1906, he presents a design for a Pacific boiler, in which the combustion chamber is 6 feet long, but in actual practice he has not ventured to use one more than half that length and the new engines for the Northern Pacific are to have combustion chambers 3 feet long or less. The class Q-1 Pacific engines on the Northern Pacific are similar to the new Pacifics, but with tubes 16 feet 8 inches long and no combustion chamber. Compared with these older engines the tube heating surface in the new Pacifics has been reduced 602 square feet or 18 per cent and the total heating surface 550 square feet or 15.6 per cent and the firebox heating surface increased 51 square feet or 28 per cent. In order to be as efficient in steam production the 51 square feet of firebox heating surface must evaporate an amount of water equivalent to that obtained from 602 square feet of tube heating surface, and one square foot of firebox heating surface must equal 11.8 square feet of tube heating surface. This expectation may be realized if efficiency is figured according to the rule suggested by Mr. H. H. Vaughan in his paper on the value of heating surface presented at the Western Railway Club, April 19, 1904. In that paper Mr. Vaughan says it would appear that if the tube heating surface be measured by the square root of its length and divided by two, a value is obtained for the heating surface which may be considered equivalent to that in the firebox and should be a fairly accurate measure of the boiler capacity. The expression for equating tube heating surface according to this theory is $h = \frac{H}{2\sqrt{l}}$ where H is the actual surface of the tubes in square feet, l their length in feet, and h the equated heating surface in terms of equivalent firebox heating surface.

Applying this to the Northern Pacific engine with plain firebox and Pacific type, we find that the total tube heating surface is equivalent to 388 square feet of firebox heating surface, which added to the actual firebox heating surface gives a total of 577 square feet. In the new Pacific engines with combustion chamber the tubes are equal to 334 square feet of firebox heating surface, which added to the actual firebox heating surface 242 equals 576, showing that on this assumption the boilers have equal evaporating values.

Coming now to the Prairie type locomotive with combustion chamber for the Northern Pacific, these engines have rather short tubes 13 feet 3 inches long and the combustion chamber is 32 inches long. The heating surface of the tubes is 2,105 square feet, and the firebox, including arch tubes, has 235 square feet, a total of 2,340. With a plain firebox in this same boiler the tubes would be 15 feet 11 inches long, tube heating surface 2,526, firebox heating surface 191. The value of the tube heating surface in terms of firebox, according to the above rule, would be 316 square feet, which added to 191 square feet equals 507 square feet. With the combustion chamber the tube heating surface in the boiler would be equivalent to 289 square feet of firebox surface, which added to 235 square feet of actual firebox surface equals 524 square feet. It would thus appear that even with tubes unusually short the superior efficiency of the added firebox surface will make the Prairie boilers as economical and as free steamers as if they had a plain firebox. It will be interesting to know if this proves to be the case in practice. If it does, then some decided advance has been made in the design of locomotive boilers for bituminous coal, and Mr. Van Alstyne should have credit for his courage in adopting the combustion chamber in such a wholesale manner and for his determined effort to find a successful method of preventing leaky tubes.—The Railway Age.

The power efficiency of certain soft coals when used in the gas-producer plant is two and one-half times greater than when used in an ordinary steam-boiler plant. This is shown by Geological Survey tests, which also develop that the softest grades of bituminous coal and lignite are equal in power production with the best grades, even surpassing anthracite for some purposes. The peat of New England may also be utilized in the gas-producer plant, and save the factories there one-third of the $50,000,000 annual coal bill for manufacturing purposes. Authorities in the United States Geological Survey at Washington claim that the use of producer gas would add hundreds of years to the duration of the American coal reserve. Suction gas is a mixture of water gas (H) and carbon monoxide (CO) into hydrogen (H) and oxygen (O), the latter being generated by the combustion of coal (C) under a lack of air. This mixture is sucked up through the apparatus by the gas engine during the loading stroke. Further experiments under a brake test with an inferior quality of coke, containing about 20 per cent of moisture and ash, showed a consumption of fuel of only 1¼ pounds per boiler horse-power per hour. Now some 300,000 horse-power are worked with suction gas in all parts of the world.

DIGEST OF THE REGULATIONS AND INSTRUCTIONS CONCERNING THE DENATURATION OF ALCOHOL.*

DENATURING BONDED WAREHOUSES.

The proprietor of any registered distillery may withdraw for denaturization from his distillery warehouse, free of tax, alcohol of not less than 180 deg. proof or strength (Sec. 2). A distiller desiring to withdraw alcohol from bond for denaturing purposes under the provisions of the act must, at his own expense, provide a denaturing bonded warehouse, to be situated on a part of the distillery premises, separated from the distillery, the distillery bonded warehouse, and all other buildings, and unprovided with windows, doors, or other openings leading into the distillery, the distillery bonded warehouse, or other room or building, except as specially provided in the act. The denatured bonded warehouse must be constructed in the same manner as distillery bonded warehouses are now constructed, and approved by the Commissioner of Internal Revenue. The capacity in wine gallons of each tank must be ascertained and marked thereon in legible letters, and each tank must be supplied with a graduated glass gage whereon the contents will be at all times correctly indicated. All openings must be so arranged that they can be securely locked. Suitable office accommodation for the officer on duty must be provided. (Sec. 2.)

The denaturing bonded warehouse is to be used only for storing denaturing alcohol, the materials used as denaturants, the denatured product, and the weighing and gaging instruments and other appliances necessary in the work of denaturing, measuring, and gaging the alcohol and denaturing materials. (Sec. 3.) The words "Denaturing bonded warehouse No. ——, district of ——," must be in plain letters in a conspicuous place on the outside of the building.

In case the distiller's bond has been executed before the erection of such warehouse the consent of the sureties to the establishment of the denaturing warehouse must be secured and entry duly signed made on the bond.

DENATURING MATERIAL ROOM.

Within the denaturing bonded warehouse a denaturing material room must be provided. This room is to be used alone for the storage of denaturing materials prior to the denaturing process. It must be perfectly secure, and must be so constructed as to render it impossible for anyone to enter during the absence of the officer in charge without the same being detected. (Sec. 4.)

At least two sets of tanks or receptacles for storing denaturing material must be provided, and each set of tanks must be of sufficient capacity in the aggregate to hold the denaturing material which it is estimated the distiller will use for thirty days. A set of tanks shall consist of one or more tanks for storing methyl alcohol, and one or more tanks of smaller capacity for storing other denaturing materials. The capacity of each tank must be ascertained and marked in legible figures on the outside. (Sec. 5.)

The tanks must not be connected with each other, and must be so constructed as to leave at least 18 inches of open space between the top of the tank and ceiling, the bottom of the tank and the floor, and the sides of the tank and walls of the denaturing material room. Each tank shall be given a number, and this number must be marked upon it. There shall be no opening at the top except such as may be necessary for dumping the denaturing material into the tank and thoroughly plunging or mixing the same. This opening must be covered so that it may be locked. Likewise the faucet through which the denaturing material is drawn must be so arranged that it can be locked. Each tank must be supplied with a graduated glass gage whereby the contents of the tank will always be shown. (Sec. 5.)

The denaturing bonded warehouse is to be under the control of the collector of the district and in the joint custody of a storekeeper, storekeeper-gager, or other designated official, and the distiller. No one may enter the warehouse except in the presence of the officer, and the warehouse and room must be kept closed and the doors securely locked except when work incidental to the process of denaturing or storing material is being carried on. Standard Sleight locks must be used for locking the denaturing bonded warehouse and the denaturing material room, and they are to be sealed in the same manner and with the same kind of seals as distillery bonded warehouses and cistern rooms are now sealed. Miller locks are to be used in securing the faucets and openings of the mixing tanks and the denaturing material tanks. Under no circumstances are the keys to be intrusted to any one except an officer duly authorized to receive them. (Sec. 6.)

Application for Approval of Denaturing Bonded Warehouse.

Whenever a distiller wishes to commence the business of denaturing alcohol he must make written application to the collector of the district in which the distillery is located for the approval of a denaturing bonded warehouse. (Sec. 7.)

Upon receipt of the application the collector will detail one of his deputies to visit the distillery and make a careful examination of the proposed denaturing bonded warehouse. (Sec. 8.)

If the deputy collector finds that the statements in the application are true and that the denaturing warehouse and material room are constructed in conformity with the law and regulations, he must make report and recommendation. (Sec. 9.)

If, after examination of the report, the collector is satisfied that the warehouse and all its parts are constructed in conformity with the law and regulations, he will indorse his approval on the application. If the Commissioner of Internal Revenue is satisfied, after examining the application and reports, that the denaturing warehouse is situated and constructed in compliance with the law and regulations, he will notify the collector of his approval. (Sec. 10.)

Denaturing Warehouse Bond to be Given.

After receipt of notice of the approval of the warehouse the distiller may withdraw from his distillery warehouse, free of tax, alcohol of not less than 180 deg. proof or strength, and may denature it in the denaturing warehouse provided he shall first execute a bond in the form prescribed by the Commissioner of Internal Revenue, with at least two sureties, unless, under the authority contained in an act approved August 13, 1894, a corporation duly authorized by the Attorney-General of the United States to become a surety on such bond shall be offered as a sole surety thereon. (Sec. 11.)

The bond must be for a penal sum of not less than double the tax on the alcohol it is estimated the distiller will denature during a period of thirty days, and in no case is the distiller to withdraw from bond for denaturing purposes and have in his denaturing warehouse in process of denaturation a quantity of alcohol the tax upon which is in excess of the penal sum of the bond. If, at any time, it should develop that the denaturing warehouse bond is insufficient the distiller must give additional bond. (Sec. 12.)

Conditions Under Which Alcohol is Withdrawn.

Not less than three hundred wine gallons of alcohol can be withdrawn at one time for denaturing purposes. (Sec. 15.) When a distiller, who is a producer of alcohol of not less than 180 degrees proof and who has given the denaturing warehouse bond, desires to remove alcohol from the distillery bonded warehouse for the purpose of denaturing, he will himself, or by his duly authorized agent, file with the collector of internal revenue of the district in which the distillery is located, a notice in triplicate.

Upon receipt of the notice the officer designated will at once proceed carefully and thoroughly to inspect each package ascertaining the actual wantage, proof, and contents without reference to the marks on the casks. (Sec. 16.) In case the spirits are withdrawn on day of entry, re-gage is not necessary, and the entry gage shall be accepted. He will make return on each copy of the order for inspection.

Upon receipt of the gager's report the distiller will indorse thereon an entry for withdrawal for transfer to denaturing bonded warehouse.

Tax Collected on Deficiency.

Upon receipt of the entry for withdrawal, and if it appear, from the report of re-gage, as made by the gager, that there is an excessive loss in any package, the collector will collect the tax on the deficiency and will indorse a permit upon each copy of the order for inspection permit for the delivery of the spirits to be transferred to denaturing bonded warehouse.

Spirits Transferred to be Marked.

Upon the receipt of the permit by the storekeeper the packages of distilled spirits described in notice of intention to withdraw may be withdrawn from distillery bonded warehouse without the payment of the tax, and may be transferred to the denaturing bonded warehouse on the distillery premises; but before the removal of the spirits from the distillery bonded warehouse, the gager, in addition to marking, cutting, and branding the marks usually required on withdrawal of spirits from warehouse, legibly and durably marks on the head of each package, in letters and figures not less than one-half an inch in length, the number of *proof* gallons then ascertained, the date of the collector's permit, the object for which the spirits were withdrawn, and his name, title, and district. (Sec. 17.)

In his record the storekeeper will enter said packages of spirits in *red ink* and will show that they were withdrawn free of tax for denaturing purposes. The storekeeper's reports will also show that the spirits were withdrawn for denaturing purposes and without the payment of the tax. Immediately upon the withdrawal of the spirits, the storekeeper will transmit the duplicate permit to the collector, who notes upon the original permit in his possession the withdrawal of the spirits therein mentioned. (Sec. 18.)

Spirits Transferred to Denaturing Bonded Warehouse.

When the packages of spirits are marked and branded in the manner indicated they are at once, in the presence and under the supervision of the storekeeper, transferred to the denaturing bonded warehouse. (Sec. 20.)

Denaturing Agents.

Completely Denatured Alcohol.

Unless otherwise specially provided, the agents used for denaturing alcohol withdrawn from bond for denaturing purposes consist of methyl alcohol and benzine in the following proportions: To every one hundred parts by volume of ethyl alcohol of the desired proof (not less than 180 deg.) there are added ten parts by volume of approved methyl alcohol and one-half of one part by volume of approved benzine; for example, to every 100 gallons of ethyl alcohol (of not less than 180 deg. proof) there are added ten gallons of approved methyl alcohol and one-half gallon of approved benzine. Alcohol thus denatured is classed as completely denatured alcohol. (Sec. 26.)

Methyl alcohol and benzine intended for use as denaturants must be submitted for chemical test and must conform with the prescribed specifications.

Denaturants Deposited in Warehouse.

As the distiller's business demands, he may bring into the denaturing bonded warehouse, in such receptacles as he may wish, any authorized denaturant. Such denaturants shall at once be deposited in the material room; thereafter they are kept in the custody and under the control of the officer in charge of the warehouse. Before any denaturant is used it must be dumped into the appropriate tank and after the contents have been thoroughly mixed, a sample of one pint taken therefrom. This sample must be forwarded to the proper officer for analysis. The officer will then securely close and seal the tank. (Sec. 27.)

No part of the contents of the tank can be used until the sample has been officially tested and approved, and report of such test made to the officer in charge of the warehouse.

If the sample is approved the contents of the tank, upon the receipt of the report, becomes an approved denaturant and the officer at once removes the seals and places the tank under government locks.

If the sample does not meet the requirements of the specifications, the officer, upon the receipt of the report of non-approval, permits the distiller, provided he desires, to treat or manipulate the proposed denaturant so as to render it a competent denaturant. In such case another sample must be submitted for approval. If the distiller does not desire to treat the denaturant further, the officer will require him immediately to remove the contents of the tank from the premises. (Sec. 27.)

Distiller to Keep Record of Denaturants.

The distiller must keep a record, in which he shall enter the date upon which he deposits any material in the tanks of the denaturing material room, the name and address of the person from whom the material was received, and the kind and quantity of the material so deposited; also he must enter in the record the date upon which he receives any material from the denaturing material room, the kind and quantity of such material so received, and the disposition made of same. (Sec. 30.)

Notice of Intention to Denature Spirits.

Before dumping any spirits or denaturants into the mixing tank, the distiller must give notice to the officer in charge of the denaturing warehouse. Upon receipt of this notice the officer in charge of the denaturing warehouse, in case of the packages of alcohol, will inspect it carefully.

Transfer of Denaturants to Mixing Tanks.

The distiller, unless pipes are used, must provide suitable gaged properly marked receptacles, metal drums being preferred, with which to transfer the denaturing agents from the material tanks to the mixing tanks. (Sec. 32.) The distiller must also provide suitable approved sealed measures of smaller capacity. The gaged receptacles are to be used where the quantity to be transferred amounts to as much as the capacity of the smallest gaged receptacle in the warehouse. The measures are to be used only when the quantity of material to be transferred is less than the capacity of the smallest gaged receptacle. (Sec. 32.)

The distiller may provide metal pipes connecting the material tanks and the mixing tanks and the denaturant may be transferred to the mixing tanks through these pipes. Such pipes must be supplied with valves, cocks, faucets, or other proper means of controlling the flow of the liquid, and such valves, cocks, or faucets must be so arranged that they can be securely locked, and the locks attached thereto must be kept fastened; the keys to be retained by the officer in charge, except when the denaturing material is being transferred to the mixing tanks. (Sec. 33.)

Before any material is transferred from a material tank to a mixing tank the officer must note the contents of the material tank as indicated by the glass gage. He will then permit the denaturant to flow into the mixing tank until the exact quantity necessary to denature the alcohol, as provided by the regulations, has been transferred. This he will ascertain by reading the gage on the material tank before the liquid has begun to flow and after the flow has been stopped. He should verify the quantity transferred by reading the gage on the mixing tank before and after the transfer. (Sec. 33.)

The distiller must provide all scales, weighing beams, and other appliances necessary for transferring the denaturing materials, gaging, or handling the alcohol, or testing any of the measures, receptacle, or gages used in the warehouse, and also a sufficient number of competent employees for the work. (Sec. 34.)

Contents of Mixing Tank to be Plunged.

The exact quality of distilled spirits contained in the packages covered by the distiller's notice having been ascertained by the officer and the spirits having been dumped into the mixing tank, and the quantities of the several denaturants prescribed by the regulations having been ascertained by calculation and added as provided to the alcohol in the mixing tank, the officer must cause the contents of the tank to be thoroughly and completely plunged and mixed by the distiller or his employees. (Sec. 35.)

Drawing Off and Gaging Denatured Product.

The distiller may from time to time, as he wishes,

* In this digest only those portions of the regulations which are of interest to the distiller and the proprietors of restoring and redenaturing plants have been retained; the rules to be observed by government offices in keeping records, etc., have been omitted as well as the regulations controlling the use of denatured alcohol in manufacturing industries.

in the presence of the officer, draw off from the tank or tanks the denatured product in quantities of not less than 50 gallons at one time, and the same must at once be gaged, stamped, and branded by the officer and removed from the premises by the distiller. (Sec. 37.)

Kind and Capacity of Packages Used.

He may use packages of a capacity of not less than five gallons or not more than one hundred and thirty-five (135) gallons, and each package must be filled to its full capacity, such wantage being allowed as may be necessary for expansion. All packages used to contain completely denatured alcohol must be painted a *light green*, and in no case is a package of any other color to be used. (Sec. 38.)

Alcohol to be Immediately Denatured.

No alcohol withdrawn from distillery warehouse for denaturing purposes will be permitted to remain in the denaturing bonded warehouse until after the close of business on the second day after the alcohol is withdrawn, but all alcohol so withdrawn must be transferred, dumped, and denatured before the close of business on said second day. (Sec. 39.)

Application for Gage of Denatured Alcohol.

When the process of denaturing has been completed and the distiller desires to have the denatured alcohol drawn off into packages and gaged, he prepares a request for such gage on the proper form. The request must state as accurately as practicable the number of packages to be drawn off and the number of wine and proof gallons contents thereof. This notice must be directed to the collector of internal revenue, but handed to the officer on duty at the denaturing bonded warehouse. (Sec. 40.)

If the officer upon examination of the proper record finds that there should be on hand the quantity of denatured alcohol covered by said notice, he proceeds to gage and stamp the several packages of denatured alcohol and make reports.

In no case will the officer gage and stamp denatured alcohol the total quantity in wine gallons of which taken together with any remnant that may be left in the denaturing tank exceeds in wine gallons the sum of the quantity of distilled spirits and denaturants dumped on that day and any remnant brought over from the previous day. (Sec. 41.)

How Denatured Alcohol is Gaged.

The gaging of denatured alcohol, where it is practicable, is conducted by weight. The officer ascertains the tare by actually weighing each package when empty. Then, after each package has been filled in his presence, he ascertains the gross weight, and, by applying the tare, the net weight.

He then ascertains the proof in the usual manner, and by applying the proof to the wine gallons content the proof gallons are ascertained.

The regulations relating to the gaging of rectified spirits, so far as they apply to apparent proof and apparent proof gallons, apply to denatured spirits. Where it is for any reason not practicable to gage denatured alcohol by weight, using the tables that apply in the case of the gaging of distilled spirits, the gaging is by rod. (Sec. 42.)

Manner of Marking Heads of Packages.

Upon each head of the package must be stenciled in *red* letters, of not less than 1½ inches in length by 1 inch in width, the words "Denatured Alcohol." (Sec. 44.) Upon the stamp head of the package must be stenciled the serial number of the package, the name of the distiller denaturing the spirits, the number of the denaturing bonded warehouse at which the spirits were denatured, and the district and State in which it is located, the date upon which the contents of the package were denatured, and the serial number of the denatured alcohol stamp.

Packages to be Numbered Serially.

Packages of denatured alcohol must be numbered serially as they are withdrawn and gaged. The serial number for every denaturing bonded warehouse must begin with number 1 with the first cask denatured, and no two or more packages denatured at the same denaturing bonded warehouse shall be numbered with the same number. A change of person or persons operating a distillery and denaturing bonded warehouse will not be taken to require a new series of numbers for the packages of spirits thereafter denatured. (Sec. 45.)

Stamps for Denatured Alcohol.

A prescribed form of stamp for denatured alcohol must be used.

Duties of Officer in Regard to Mixing Tank.

The mixing tank is absolutely under control of the officer in charge of the warehouse. If it becomes necessary for him to leave the denaturing bonded warehouse during the process of denaturing, he must close and lock all openings to said tank and must retain the key in his possession, and all other persons must leave the building.

When the work of the day is done the officer must ascertain the quantity in wine and proof gallons of any remnant of denatured alcohol that may be on hand, and on each day before any further denaturing is done he must, before anything is dumped into the denaturing tank, ascertain the quantity in wine and proof gallons of any remnant that may be in the tank. (Sec. 49.)

Denatured Alcohol to be Removed from Warehouse.

Not later than the close of business on the day following that upon which the work of drawing off and gaging the denatured spirits is completed, the distiller must remove the denatured alcohol from the denaturing bonded warehouse. He may either remove the alcohol to a building off the distillery premises, where he can dispose of it as the demands of the trade require, or he may dispose of it in stamped packages direct to the trade from the denaturing bonded warehouse. (Sec. 51.)

Record Showing Alcohol Received and Disposed of to be Kept by Distiller.

The distiller must keep a record in which he shows, respectively, all denatured alcohol received from the officer in charge of the warehouse and disposed of by him. (Sec. 52.)

The entries must be made before the goods are removed from the denaturing bonded warehouse, if sold direct from there, or from the salesroom of the distiller off the premises, if sold from there. (Sec. 52.)

Monthly Transcript.

Before the tenth day of each month the distiller must prepare a complete transcript of this record, must swear to it, and must forward it to the collector of the district. (Sec. 54.)

Collectors to Keep Accounts with Denaturers.

Collectors must keep an exact account with each denaturer of alcohol on record in such manner as to be constantly advised as to the state of the denaturer's business, and they must exercise such supervision over the issue of stamps for denatured alcohol as will prevent fraud in their use. (Sec. 55.)

Manner of Handling and Testing Samples of Denaturants.

When the distiller at any denaturing bonded warehouse has dumped into any material tank a quantity of a proposed denaturant the officer draws a sample from the tank. A heavy glass bottle, which must be provided by the distiller, is used as a container for the sample. The bottle must be securely closed and sealed, and a label affixed thereto, showing the serial number of the denaturing material tank from which the sample was taken, the date it was drawn from the tank, and the name of the officer sending it. The sample must be securely packed, and sent by express to the most convenient laboratory for test. All expenses in connection with the forwarding of samples must be borne by the distiller. As soon as practicable the necessary tests of the sample are made in the laboratory and report made of its character. One copy of the report should be sent to the collector of internal revenue of the district, and the other should be sent to the officer in charge of the denaturing bonded warehouse. (Sec. 57.)

(To be continued.)

ENGINEERING NOTES.

In certain kinds of manufacturing plants, having many hot, greasy drips from machines, feed water is made to flow through the pipes of a horizontal heater, the boiler feed water filling the space between the tubes and the shell. Exhaust from pumps and other apparatus may be discharged through the same heater if desired. The coldest feed water surrounds the lower pipes containing the least hot drips, so that they pass from the heater to the sewer at relatively low temperatures, having transferred most of their heat to the feed water. The flow of hot condensation through such heaters is apt to be irregular, and in most cases would be hardly sufficient to bring the feed water to the desired temperature, therefore it is customary to use a regular closed heater as a reheater supplied with exhaust steam from the main engine. Valved by-passes are provided for use in case of repairs or cleaning.

In considering producer gas it is well to show clearly what is the difference between illuminating gas—that which we are accustomed to call "coal gas"—and those other gases called producer gases, but which the French have perhaps more happily named "poor gases," a qualification which explains that they are of less calorific value. For this is the great distinction between the gas used in our streets and the producer gas manufactured especially for the purpose of driving engines. The composition of illuminating gas varies considerably according to the locality, and of late efforts have been made so to alter its composition as to lower its calorific value, although it is only fair to say that at the same time the price of gas has also been usually lowered. The advent of the incandescent mantle was the chief cause of this so-called cheapening of coal gas. It may not be altogether inopportune to point out to the owners of gas engines using coal gas that it is obviously to their interests to keep a check upon the calorific value of the gas for which they must pay. Calorific value of coal gas at 32 deg. F. and at atmospheric pressure varies from 5,000 to 5,600 calories per cubic meter, which is equivalent to about from 20,000 to 25,000 B.T.U. per 35.3 cubic feet. Coal gas contains hydrogen, methane, in large proportion, and carbon monoxide, carbon dioxide, and nitrogen in small proportion. To show how these proportions vary in different cities, it may be mentioned that the street gas in Paris contains fifty-two parts of hydrogen, that of London forty-eight, while that of New York contains only forty. Not only, therefore, does the calorific value of coal gas vary from city to city, but indisputable records and experiments have proved that in the same place within a few hours there have been variations of 10 per cent in the value of the coal gas supplied at that point.

ELECTRICAL NOTES.

The new Orbe hydraulic plant now ranks among the large hydro-electric stations of Switzerland, and it has been completed within a recent period. It utilizes the water from two lakes, the Joux and the Brenets. The Joux lake can afford a difference of level of three feet or more, and has ten million square yards surface. An artificial canal of 7 square yards section leads from the dam which is built across the northern part of the lake. This canal is entirely underground, and is about 1½ miles long, and it delivers about twenty-five cubic yards per second. At the end of the canal is a settling reservoir, and from here three penstocks lead down to the turbine station. The water head is about 700 feet, and the plant can furnish 5,000 horse-power at high water. At present there are seven main turbine-dynamo units in the plant. Of these, five groups having Escher-Wyss wheels with horizontal shaft have a capacity of 750 kilowatts, and run at 375 revolutions per minute, while the remaining two groups are rated at 120 kilowatts and run at 750 revolutions per minute. With the larger wheels, Oerlikon alternators of 750 kilowatts are used, and these dynamos give three-phase current at 13,500 volts and 50 cycles. They are of the inductor type, in which the revolving part contains no wire winding. For exciting the fields smaller dynamos are provided. A switchboard for handling the circuits is located in an upper galley. The distributing lines leaving the station are operated on the three-phase or the single-phase system. A large area containing 212 communes and 92,000 inhabitants is covered by the overhead lines. In this region there are 240 transformer posts for lowering the tension to 400 or 250 volts. The current is used mainly for incandescent lamps and motors.

So much is being said these days about electric cooking and heating devices and their introduction by central station companies, it will not be amiss to call attention to some little details which, until they are attended to, are sure to hamper the introduction of electric cooking and heating devices where a number are to be used in a household; or, in other words, where special heating circuits are necessary. It must be generally conceded in the first place that no very extensive use of electric cooking appliances will be made until special heating circuits are provided in houses. There are lamentably few houses with such circuits at the present time, and the details of wiring and fittings in connection therewith have been given insufficient attention by the manufacturers of heating appliances. In fact, it seems as if the difficulties of making the appliances themselves up until recently had been so great that but little attention had been given to getting current to them. Let the would-be user of electric heating appliances who intends to put in special circuits and do everything in accordance with underwriters' rules search the latest supplement to the National Code for a list of approved plugs and receptacles which will carry over three amperes and are suitable for use in a residence where the child with the hairpin is one of the factors to be reckoned with. To be sure, he finds several open or easily opened flush receptacles which have been approved for ten amperes. Beyond that there is nothing on the list, but we are glad to learn that this want will be filled within a short time. The whole subject of wiring for heating appliances is in a stage of development from which it should be released as soon as possible by the working out of acceptable fittings and plans of installation suitable for ordinary dwellings.—Electrical World.

When in the seventies electric lighting first began to assume a commercial aspect, no engineer appears to have dreamed of driving a dynamo by any other method than by applying a pulley to its shaft, and belting this pulley to a pulley on the shaft of a steam engine either directly or through some countershaft. It is true that in 1862 Holmes, the first engineer to apply electric lighting to English lighthouses, showed his magneto-electric machine driven direct on the end of the shaft of a steam engine running at 110 revolutions per minute. But his example was not followed by those who came after. The steam engines of that day were almost without exception slow-speed engines, while the early dynamos required high speeds; and there was no choice but to drive by gearing or belts. The state of steam engine practice at the end of the seventies appears nowadays truly remarkable. If we except the locomotive and marine types of engines as being out of consideration for the purpose, we are left with the types of stationary engine then in vogue for pumping and blowing, for the driving of textile factories and rolling mills. Winton's well-known textbook, "Modern Steam Practice and Engineering," which went through several editions, gives a remarkable view of the practice as it obtained twenty-five years ago. In the edition of 1883 the typical examples of stationary engines are instructive. On page 288 there are described the engines of the Dowlais Iron Works; a blowing engine of 650 nominal horse-power, making 22 R.P.M., and a rolling engine of 1,000 nominal horse-power, making 24 R.P.M., both working with steam at 40 pounds per square inch. On page 300 is mentioned a 160-horse-power engine at the Royal Gun Factory at Woolwich, making 21 R.P.M., and also taking steam at 40 pounds per square inch. As a novelty is mentioned the compound engine, working the rolling mill of the Steel Company of Scotland, at Hallside, near Glasgow, built by Miller, of Coatbridge. This was of 3,000 horse-power, at 50 to 60 R.P.M., and using steam at 120 pounds per square inch. Smaller steam engines undoubtedly ran faster; but the practice then was totally different from that of to-day.

TRADE NOTES AND FORMULÆ.

Polish for Shoe Soles.—Melt 1 part of stearine in an iron pot over a fire; remove the pot and place it in another room or in the open air; add 4 to 5 parts of benzine, stirring vigorously. Paint the soles with this mixture and polish with a linen rag.

Or dissolve together 5 parts stearine and 1 part of white beeswax. This mixture will be found admirably adapted for polishing shoe soles. A little of the composition should be cut off and rubbed into the soles and the latter afterward polished with a clean rag. Both these preparations are far preferable to the ordinary tragacanth solutions.

To Deodorize Petroleum.—Girard (Chem. Revue f. d. Fett- und Harzind.) has succeeded in deodorizing black Russian petroleum by heating it to 150 deg. C. (302 deg. F.) in a retort with an acid solution of ferric chloride. About 1.5 per cent passed over. While the oil was entirely odorless, the distillate had a very powerful odor, and consisted probably of methyl derivatives of thyophen. Pyrrol and pyridin bases are also said to be present in petroleum. The attempt to eliminate the sulphur from petroleum in order to remove the smell has not always been successful. The offensive smell may be due to various causes, and it is therefore impossible to formulate a method which would be applicable to every kind of oil.

Indestructible Writing Tablets for Ink.—Apply to the ruled side of a sheet of paper a mass composed of: 80 parts by weight of white linseed oil, 10 parts purified turpentine, 4 parts chemically pure glycerine, 3 parts benzine, 3 parts American petroleum. Allow to dry for about five days, and spread on the same side a thick mass consisting of: 70 parts linseed oil varnish, 10 parts turpentine oil, and 100 parts zinc white. Only the lines will then be visible through the paper. Then cover two pieces of cardboard with the paper, and stick them together in such a manner that the edges of the paper are nowhere exposed to view. This will prevent the turning up of the edges of the cardboard and the disappearance of the lines when the tablet or "ink slate" is cleaned by washing off. To enable the tablet to be used for writing, a mixture of white shellac, pure alcohol, petroleum, and benzine is finally applied to the paper.

Cement for Leather.—A solution of gutta-percha in carbon disulphide, having the consistency of syrup and sufficiently diluted with petroleum, is extremely serviceable as a cement for leather. A thin layer of the cement should be quickly applied and the pieces of leather pressed firmly together.

The following asphalt cement may also be used: Asphalt, 12 parts; colophony, 10 parts; gutta-percha, 40 parts; carbon disulphide, 150 parts; petroleum, 60 parts. These ingredients, omitting the carbon disulphide, are first treated for several hours with petroleum in a flask in a bath of boiling water; the thick mass is then allowed to cool, the carbon disulphide is added, and the whole is left to stand for a day. It should be frequently shaken. The leather strips, previously roughened, should be coated evenly with the cement and afterward exposed to vigorous pressure between warm rollers. They will then firmly adhere.

Maizine.—If maize flour, from which the oil has been previously removed by means of benzol, is steeped in boiling amyl alcohol, a portion of the protein of the maize will be dissolved, while the gluten will remain undissolved. The albuminoid substance, soluble in boiling amyl alcohol and precipitated from this solution by benzol, has received the name of maizine. Maizine consists of a white powder, not hygroscopic, soluble in ethyl and other alcohols and also in acetic acid. It is an excellent substance for wrapping round medicines, and is used in the preparation of capsules which are intended to act directly on the bowels and not on the stomach. A 40 per cent solution of maizine can be made with ethyl alcohol, while even a 50 per cent solution can be made with acetic acid. These solutions are very viscid and are well adapted for coating pills without perceptibly increasing their size. If a maizine solution is boiled down, we obtain a mass from which capsules can be made for containing volatile oils, ether, aqueous solutions, and the like; alcohol and alcoholic solutions can of course not be inclosed in maizine capsules, as they would dissolve the latter.

New Agglutinant.—An agglutinant introduced by the Italian firm Giglio & Zaouche, is composed of the following substances: Torrefied potato fecula, ordinary colophony, acetic acid (vinegar), tallow, vegetable or animal, strong glue, powdered Turkey glue.

The following is a sample of the process: 2 parts by weight of torrefied potato fecula are mixed in solution with 100 parts of boiling water.

A second solution is prepared by dissolving 15 parts of colophony or any kind of rosin in 3 parts of ordinary acetic acid or vinegar diluted.

A third solution is prepared by dissolving hot, in 2 parts of strong glue, 1 part of vegetable or animal tallow, in order to keep it fluid.

The last two solutions are mingled at their temperature and 3 parts of Turkey glue are added to form a paste consistent at the ordinary temperature. This mass, when it is to be used, is submitted to a temperature of 100 deg. C., and when softened the first solution is added gradually. The composition is to be mixed hot or cold with the pulverulent matter to be agglomerated in the proportion of about 8 per cent if coal of any kind is to be used. Briquettes of all forms and dimensions are manufactured by means of special machines or by any other process.

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